TED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
F. A. SILCOX, CHIEF

TELEPHONE HANDBOOK

1936

PREPARED BY
DIVISION OF ENGINEERING
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PREFACE

The Telephone Handbook was prepared by C. M. Allen, Telephone Engineer, Region Six, at the request of the Chief.

The contents were reviewed by the Regional Offices of the Forest Service. The original draft of the Handbook, together with all suggestions and criticisms offered by the Regions, was submitted to the American Telephone and Telegraph Company for further review and criticism. Following a conference with the Engineers of the American Telephone and Telegraph Company and a review of the subject of specifications and preservative treatment of poles by the Forest Products Laboratory, the handbook was prepared in its present form by Harold L. Friend, Division of Engineering of the Washington Office.

Acknowledgment is made for valuable aid and information to the Engineers of the Regional Offices, and the American Telephone and Telegraph Company and the Forest Products Laboratory.

Washington, D. C.
August, 1936

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TELEPHONE HANDBOOK

PURPOSE

The purposes of the handbook are:

A. To set forth certain broad policies.
B. To describe certain approved types of telephone construction and maintenance, including installation of instruments, and to establish standard specifications for the more important types.
C. To explain briefly the fundamental principles involved in the operation of telephone lines and instruments.
D. To furnish instructions for locating and clearing trouble.
E. To describe special methods used, and practices followed, in different regions, which are adaptable to the varying field conditions.

SECTION I - POLICY AND GENERAL INSTRUCTIONS

1. General Policy

A telephone system is indispensable in the protection and administration of the National Forests. In localities where the telephone service is required and the public utilities are not in a position to provide the desired facilities, Forest Service lines should be provided. They should be so constructed and maintained as to insure satisfactory communication.

2. Priority

In financing the extension of the system, the following priorities will govern:

A. Lines to insure more effective fire control
B. Lines to facilitate administration

3. Construction Along Highways

Telephone lines must not be constructed within 200 feet of the center of Class 1 or Class 2 highways, or within 100 feet of the center of Class 3 highways without the prior approval of the Regional Forester. Necessity for the construction must be proven, and proper precautions must be taken to preserve roadside scenic values. The instructions in Article 26 should be carefully observed.

4. Temporary Lines

Temporary lines should be constructed to establish communication to camps of crews forming important parts of the fire control organization. Insulated emergency wire, placed in accordance with the instructions covering stringing of emergency wire lines, may be used, or bare line wire may be placed in accordance with the methods prescribed for permanent lines on the following pages. The selection of the plan to be used in any particular case should be based on the urgency of the need, the relative costs of the two methods, and the availability of materials and construction forces for doing the work.

5. Private Connections

Individuals, companies, and corporations which are a part of the fire control organization as outlined by the fire plan may be allowed connections to and communication over Forest Service lines either under free or paid permit as may be determined by the Regional Forester. No private lines shall be connected directly to Forest Service lines, except at and through switching stations, without the prior approval of the Regional Forester.

Permits granting to parties outside of the service the privilege of attaching instruments will be issued in accordance with the special-use regulations or cooperative agreements, which, in all cases, should stipulate in addition to the printed requirements the following:

A. Type of construction and maintenance consistent with Forest Service standards and work done in a manner satisfactory to the Forest Service.

B. Type of instrument to be attached and methods of installation.

C. Fire control service expected.

D. Rate of payment, standardized for the region by the Regional Forester.

6. Use of the Handbook

The specifications and instructions given herein are confined to the more obvious details and the major principles of telephone line construction, equipment installation, and maintenance. They are based upon methods and principles of which the worth and general applicability have been proven by experience.

Field officers are not expected to memorize the contents of this handbook but they are expected to remember:

A. That the handbook is available.

B. That it is to be consulted and studied before starting a job.

C. That every man placed in charge of telephone work must have a copy of it, supplemented, where necessary, by specific written instructions to indicate the parts of the handbook that are applicable to his job.

D. That the instructions it contains will govern on all jobs unless physical conditions clearly prevent.

The burden of proof of inapplicability will always be upon the officer who is responsible for getting the work done in accordance with the handbook specifications and instructions.

SECTION II - PLANS

7. General Plans:

A telephone system plan should be developed for each forest as conditions warrant. A standard form of plan, complete in all details, will not be prescribed. As a minimum requirement, however, a map should be prepared for each forest which will be called "The Plan and Progress Map". It should show the location of each telephone line, with separate symbols for "proposed" and "completed". Forest Service lines should be shown by one color and private lines by another color. In carrying out the plan, the proposed lines should be constructed only at such times as the need for them has been demonstrated.

Some of the important points to be considered in the development of telephone system plans are:

A. The relation of the proposed line to existing systems, private and Forest Service, local and interforest lines considered.

B. Load factors, or the effect that additional mileage and instrument load will have upon the existing systems.

C. Switching arrangements needed at different points to break up the "load" and to give clear right of way over trunk lines.

D. Development required to centralize, so far as practicable, switching arrangements at points for central fire dispatchers.

E. Avoidance of high-voltage electric transmission and telegraph lines as far as practicable.

F. All other factors given due weight, the routes which will render the greatest advantage:

(a) as bases from which to extend emergency lines in case of fire,

(b) for lines paralleling possible or existing patrol routes,

(c) as trunk lines from which to extend permanent branches.

G. General accessibility of the route.

The Regional Forester will make such check of the telephone system plans as may be necessary to insure adequacy and economy of development and proper coordination of plans between the systems of different forests and with private or commercial lines.

8. Line Capacity:

Each telephone or extension bell connected to a line adds a load to the line since it consumes a certain amount of electric energy. Too many instruments connected to a line, load it so heavily electrically that ringing and talking over the line may be seriously hampered. Each connected telephone usually means added use or traffic. A heavy traffic load is a most objectionable form of interference. In view of these facts, every line has its limit as to the number of telephones, extension bells, and repeating coils that can be carried; accordingly, "line capacity" is a material factor to be dealt with in the working out of forest communication plans. Lines which are free from all forms of physical interference have the greatest capacity. Interference may be caused by brush, poor insulation, static, induction from high-voltage power lines, or cross-talk from adjacent telephone lines. These elements in addition to the traffic load, must be considered in estimating the capacity of a given line. On principal trunk lines, the traffic or use load is a factor calling for regulation by careful planning and supervision.

The most recent development for calculating telephone line capacity uses the decibel unit (db) as a measuring device. This is simply a unit of load. Each item of load is considered and the sum of the items is the total line load.

The following decibel ratings are considered close enough for practical purposes:-

Parts of system	Average db. load
Wire, #9 Iron - EBB grounded - per mile	0.200
Wire, #9 Iron - EBB metallic - per mile	0.247
Wire, #12 Copper covered grounded - per mile	0.200
Wire, #12 Copper covered metallic - per mile	0.220
Wire, #10 Copper metallic - per mile	0.071
Ringer, 2500 ohm each	1.000
Spur lines each	1.000
Repeating coil each	0.500

A line load of 31 db is standard, and the speech level is very satisfactory. In cases of emergency, the line can be loaded to 35 db and still maintain communication. It is better to plan a new line for a load of less than 31 db to allow for the installation of several extra emergency telephones, or some extension of the line without exceeding the db limit.

Except when needed, all instruments at unoccupied camps or other points will be cut off the line by means of a switch. Such instruments, depending upon circumstances, may or may not be counted as a part of the ordinary load, in calculating a line's carrying capacity.

9. Line Length:

The principal factors to be considered in determining the maximum length of single units of Forest Service telephone lines which may be operated satisfactorily are:

A. Line Leakage

B. Interference

C. Number of telephones and other equipment connected to the circuit.

Ordinarily, lines extending through dense forests may be operated in lengths ranging from 40 to 50 miles provided they are not too heavily loaded. Through more open country, where the probability of line leakage due to brush is less, lines up to 75 miles in length may be operated satisfactorily. If lines are heavily loaded or if points farther apart are to be reached, the installation of a repeater at an intermediate point may be advisable. A 50 mile grounded circuit line is about the limit for a line that can be operated satisfactorily over high divides or in any other localities where a considerable volume of static interference may be encountered.

SECTION III - STANDARDS AND SPECIFICATIONS

10. Type of Line:

Except for line interference, and in localities where it is not possible to make a satisfactory telephone ground, it is possible to talk and ring as far over a grounded circuit or one-wire line as over a metallic circuit or two-wire line. Therefore, with the above exceptions, grounded circuit lines will be considered as the Forest Service standard.

Tree lines will be used wherever practicable.

Pole lines will be built only where:

1. Suitable trees are not available on a feasible and practical route.

2. It is necessary to construct metallic circuit lines to eliminate electrical interference, static, and serious cross-talk.

11. Line Wire:

No. 9 BW gauge, diameter 0.148 inch, galvanized EBB iron and No. 12 AW gauge, diameter 0.081 inch, copper covered wires will ordinarily be used in the construction of new circuits. Costs will be the governing factor except that the copper covered wire should be used where there is a chance of corrosion from salt air, acid fumes, etc.

No. 10, AW gauge, diameter 0.102 inch, solid copper may be used on exceedingly long metallic circuits on pole leads where it is necessary to obtain proper conductivity or where it is required in contacting commercial company poles.

No. 6 AW gauge, diameter 0.162 inch, and No. 8 AW gauge, diameter 0.128 inch, copper covered wire may be used for long spans and in heavy loading areas.

When other than No. 9 iron wire or No. 12 copper covered wire is used, prior approval must be obtained from the Regional Forester.

12. Line Connections:

Experience indicates that unless splices are carefully made by experienced men, 25% to 50% of the efficiency of the line may be lost after a few years. This difficulty is not altogether overcome by soldering, due to the fact that a poor soldering job, such as would be done by inexperienced labor, usually results in a higher resistant splice than before.

For the above reasons, the single tube type sleeve is recommended as a standard for splicing all line wire of the same kind and size. The use of this type of equipment affords the best assurance of proper line wire splices even when used by inexperienced men. The conductivity and strength of this type of splice is greater than the line wire itself.

Where it is necessary to splice wires or different sizes, or at dead end points, the double tube sleeve with twisted joint is the standard connection.

At points where galvanized iron wire and copper covered wire are to be joined together, both line wires should be dead-ended, and the ends joined together by soldering or by means of a bridging connector.

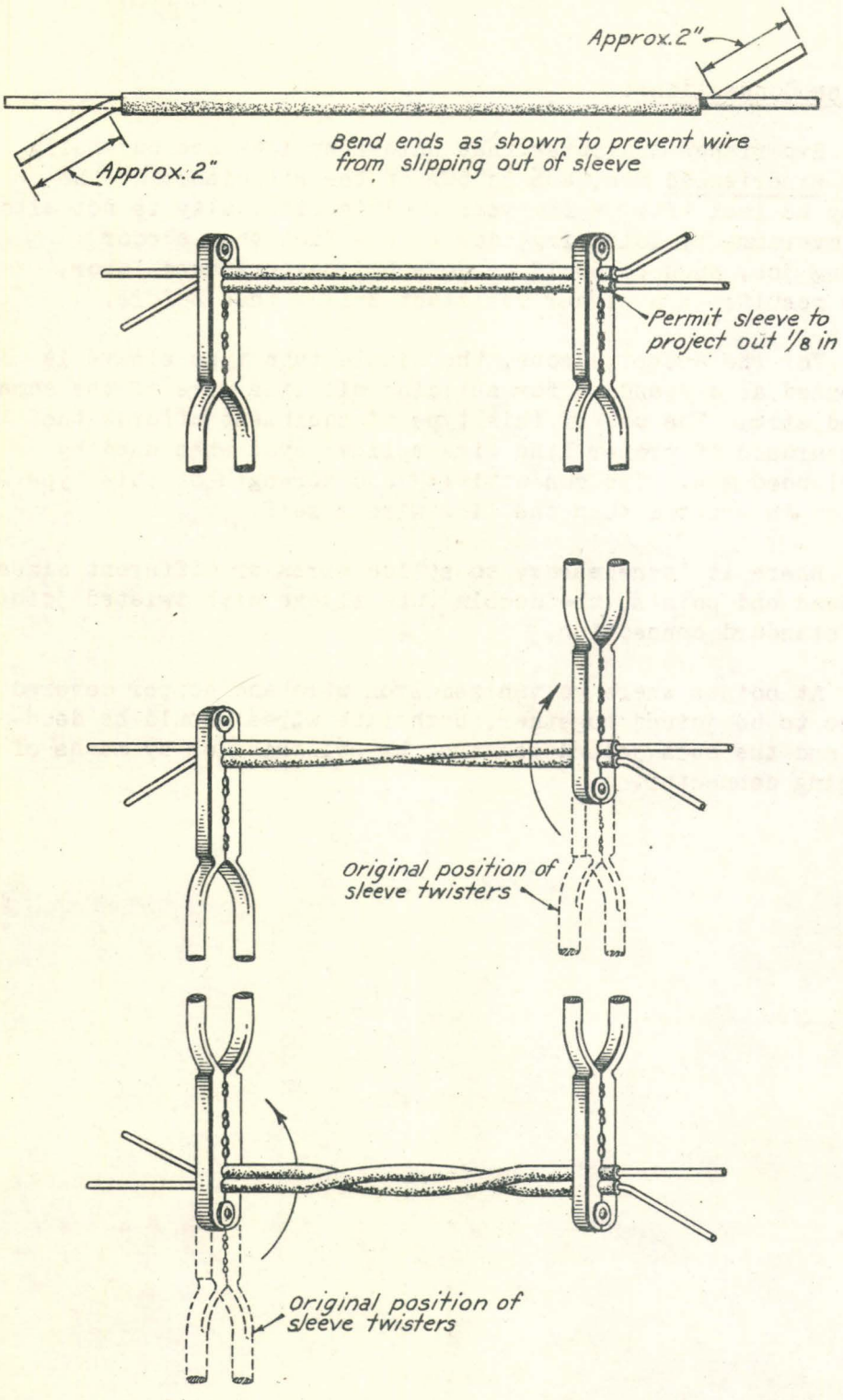


FIGURE 1

MAKING TWISTED SLEEVE JOINT

SECTION IV - TREE LINE CONSTRUCTION

13. Essential Features

The essential features of this type of construction are:

A. A slack line, supported by trees instead of poles.

B. Insulators hung so as to swing freely from the supporting tree and through which the line wire may easily slide in either direction, as contrasted with the fixed tie of a tight line to the standard type of insulators common in pole line construction.

C. Approximately uniform span lengths.

14. Location of Lines

Lines will be located:

A. To minimize trouble from high winds, falling timber, deep snow, snow and land slides, proximity of other grounded telephone and telegraph lines and electric transmission lines. Telegraph and electric transmission lines should be avoided, even at considerable additional expense.

B. Adjacent to and in plain view from roads and trails. Short cuts along which the line will be totally obscured from view from a road or trail should be avoided as a rule. Savings in construction costs can sometimes be made by short-cutting across canyons, switchbacks, etc., but such savings must be very material indeed to justify placing the line out of sight of the road or trail.

C. Along roads and trails so that the wire will not fall across the traveled way if hangers should break or if the line is borne down by the weight of snow or fallen timber.

When the telephone line is at the outer bend of a stream, road or trail, a shield tree should be arranged for, where practicable, to prevent the line from swinging into the stream, road or trail, if it pulls off the tie tree.

D. To avoid crossing railroad tracks and main highways, if possible,

E. Along the lower side of the railroad tracks, to keep wires from falling on tracks in case of breakage.

F. To avoid the use of poles for tree circuits. It is a better plan to skirt a meadow or park by hanging the wire on bordering trees than to seek straight alignment and higher standards of visibility of the proposed line by building on poles across such openings. Likewise, rather than cross rock stretches which necessitate blasting for poles, or the construction of tripods, detour to trees if they are avilable along reasonably accessible routes.

Two men should do the locating. They should provide themselves with a piece of light wire, 140 feet long, with a hand hold on each end. The boss locator should always be on the rear end of the line. The man ahead should drag out the line and when he has come to the end of it should make tentative selection of a tie tree, conferring back and forth with the locator. When the locator has advanced to the selected tree, he should make the final selection and indicate by a blaze on the face of the tree, the side on which the line is to be hung. The reason for this is that only by sighting both ways from the tie tree can the locator determine which side is the best on which to hang the line. Pacing does not result in sufficiently accurate spans to give satisfactory construction.

15. Clearing

Do not swamp out a separate right of way for a telephone line along roads or trails in whole or in part unless to do so is necessary in order to carry out the instructions of "Location of Lines". Utilize the clearing of the road or trails as much as these instructions permit.

So far as practicable, do all necessary clearing for the line prior to the unreeling of the wire. To do so facilitates the stringing and the raising of the wire into place. The ties and tree pins may also be more easily attached after clearing is partially done. When the wire is in place, cut any remaining obstruction to a distance of not less than four feet from the wire. Be sure to cut away all branches which might possibly interfere with the line when snow laden. Rapid growth trees under the wire will also be removed. Thorough line clearing is essential to prevent line leakage (loss of the ringing and talking current) which will result if the wire is allowed to come in contact with branches and tree trunks.

Trimming is necessary only on the line side of the tie trees and on obstructing intermediate trees. Tie trees on main traveled roads, however, should be neatly trimmed. Where aesthetic considerations are not involved, it is permissible to leave sufficient stubs or branches to facilitate climbing.

Where practicable, it is desirable to fall all snags, particularly rotten ones, which may later fall on the line wire. The falling of snags is usually practicable except in the old Douglas-fir burns in Oregon and Washington and in the vast deadenings of Idaho and Montana. Many snags may be cheaply disposed of along telephone lines by burning them down if the job is undertaken during a period of no fire danger.

16. Selection of Tie Trees

Suggestions for the selection of tie trees along a trail or road will be found in Figures 2 and 3.

Tie trees which throw a sharp turn in the line should be avoided. So far as practicable avoid large trees which are difficult to climb. If necessary to use large trees, the method shown in Figure 4 is applicable. On account of the rapid growth of sprouts on oaks, alder, vine maple, etc., these trees should not be used if other species are available. If suitable material is at hand, it is better practice to build tripods as shown in Figure 5, or set occasional poles, rather than to use unusually long spans. This is especially applicable in snow country, or in places where long detours will place the line out of sight in inaccessible locations. If poles are used, suspend the wire in the same manner as described for trees.

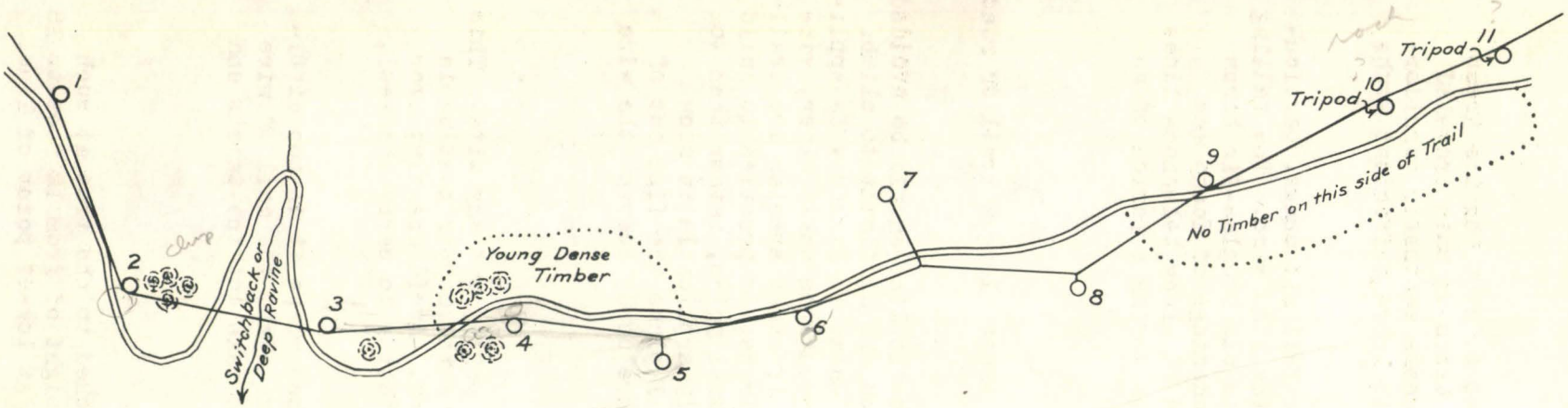
17. Stringing Wire

Care should be taken in handling and paying out any wire. This is especially true of copper-covered wire, as the copper coating is easily scraped off, allowing the core to rust. Avoid dragging over rocks or around sharp turns. It is always better to carry the reel, allowing the wire to drop off behind.

Wire may be payed out by hand in places where it is too difficult to take a reel. When this method is employed, the coil of wire should be reversed once in every 10 loops to take out the twists and avoid kinks.

18. Height of Wire

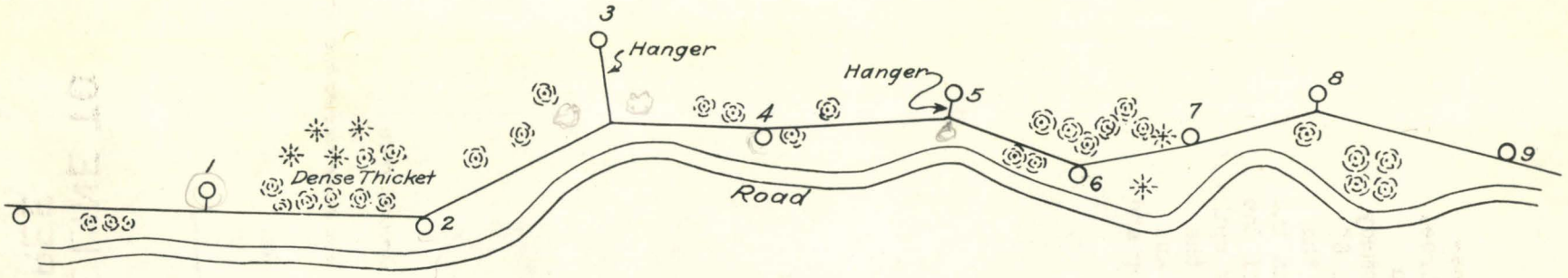
The hanger should ordinarily be attached to the tree at such elevation that the insulator will be at a height of from 12 feet to 15 feet. This will secure a ground clearance, at lowest point of line, of about 12 feet.



No. of Tie Tree	Type of Tie Used	Reason for Selection of Tree and Type of Tie
1	See fig. 8	Tree complies with instructions.
2	" " 4	Too large to climb.
3	" " 11	Tree OK and tie can be high enough to clear trail.
4	" " 11	Tree pin necessary account excessive clearing costs if line is put behind tree.
5	" " 9	Set pole; no suitable tie trees available; impossible to set pole near trail account of rock.
6	" " 11	Tree pin necessary account no other available tie trees.
7	" " 9	Long hanger ("Swinger"), otherwise excessive clearing cost and line would cross trail twice.
8	" " 9	No other trees available.
9	" " 8	Necessary to cross trail account no other trees available.
10	" " 9 or 12	No trees available - rocky ground.
11	" " 9 or 12	No trees available - rocky ground.

FIGURE 2

SUGGESTIONS FOR SELECTION OF TIE TREES FOR LINE ALONG A TRAIL



	No. of Tie Trees	Type of Tie Used	Reason for Selection of Tree and Type of Tie
Spring pole	1	See fig. 9	Long hanger (Tie wire) necessary account undergrowth, etc., near road.
S	2	" " 8	Standard tie.
L	3	" " 9	Long hanger necessary account young timber prevents hanging line close to tree. No other suitable tree available.
S	4	" " 8	Standard tie.
L	5	" " 9	Long hanger necessary account dense timber near tie tree.
S	6	" " 8	Standard tie.
TP	7	" " 11	Tree pin.
S	8	" " 8 or 9	Long tie or standard tie.
P	9	" " 8	Set pole, necessary account no suitable tie trees.

FIGURE 3

SUGGESTIONS FOR SELECTION OF TIE TREES FOR LINE ALONG A ROAD

In telephone construction it is often necessary to tie to an old snag or to a large tree. These are so solid that an insulator often pulls off that kind of a tie tree. The remedy is: Take a small pole approximately 4" to 6" in diameter by about 12' to 16' long; tie the insulator to the small end and spike or tie the base of the pole to the tree at the base of the tree with a piece of wire, and then tie or spike the pole to the tree about 3' to 4' above the lower tie. This avoids climbing the tree and gives a spring pole. In that way insulator and wire breakage is reduced.

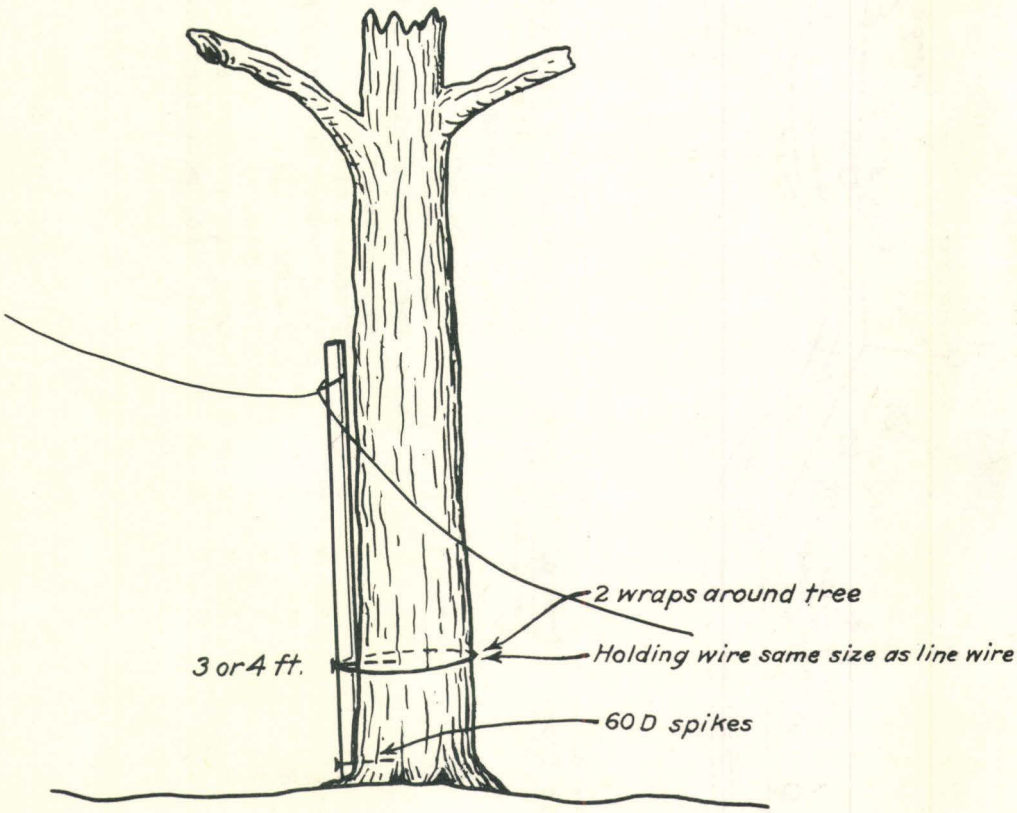


FIGURE 4

METHOD OF TYING TELEPHONE LINE TO AN OLD SNAG OR A LARGE TREE

Spring Pole

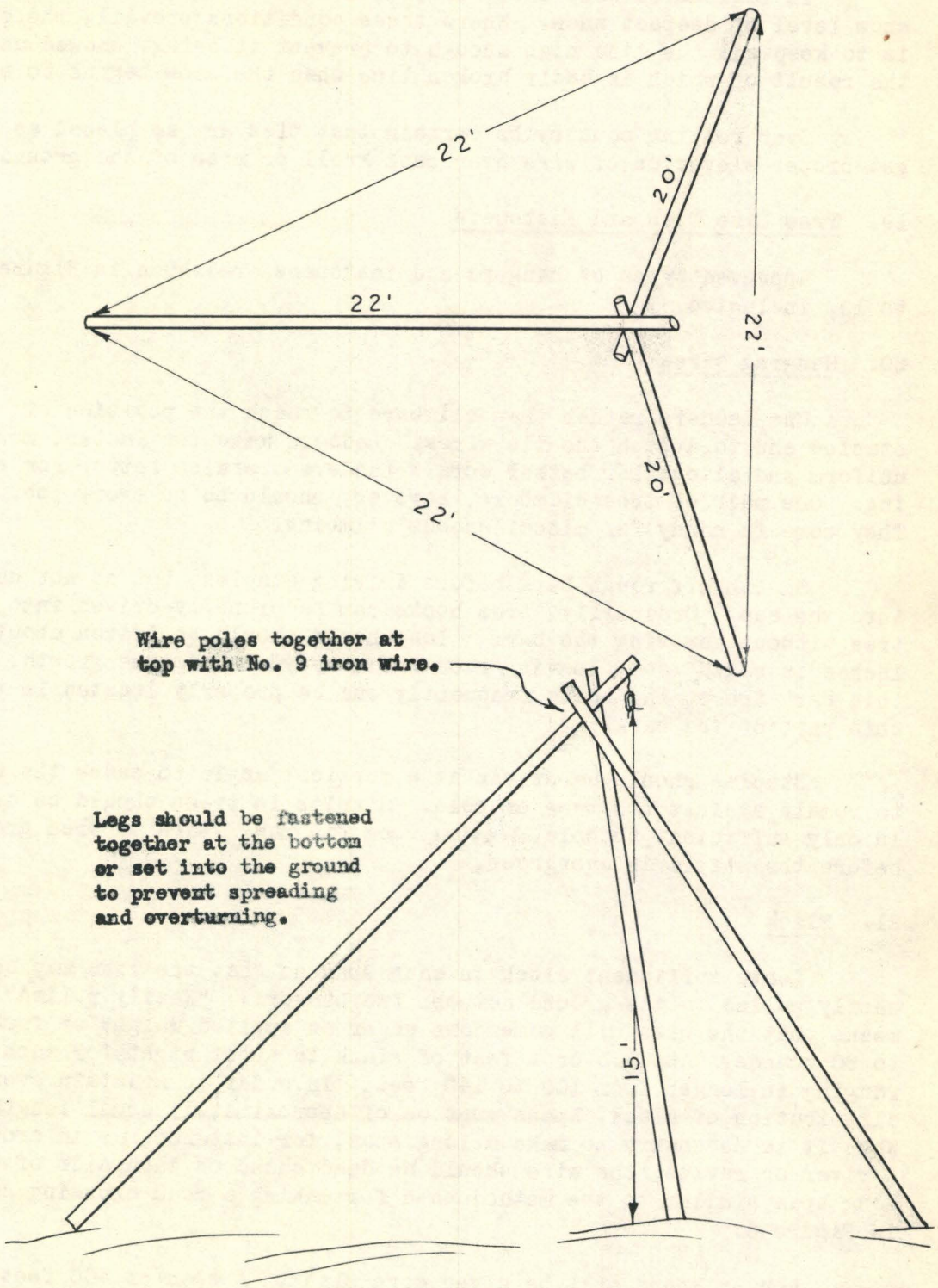


FIGURE 5

TRIPOD CONSTRUCTION

In regions of deep snow, if practicable, hang the wire above the snow level of deepest snow. Where these conditions prevail, the object is to keep all the line high enough to prevent it being "snowed under", the result of which is badly broken line when the snow begins to settle.

Over rolling country be certain that ties are so placed as to get proper elevation of wire over each knoll or rise of the ground.

19. Tree Line Ties and Fasteners

Approved types of hangers and fasteners are shown in Figures 7 to 13, inclusive.

20. Hanging Wires

Use ladders rather than climbers to reach the position of staples and to attach the tie wires. Ladders make for faster, more uniform and altogether better work. Ladders are also better for clearing. One pair of tree climbers, however, should be on every job. They come in handy for miscellaneous climbing.

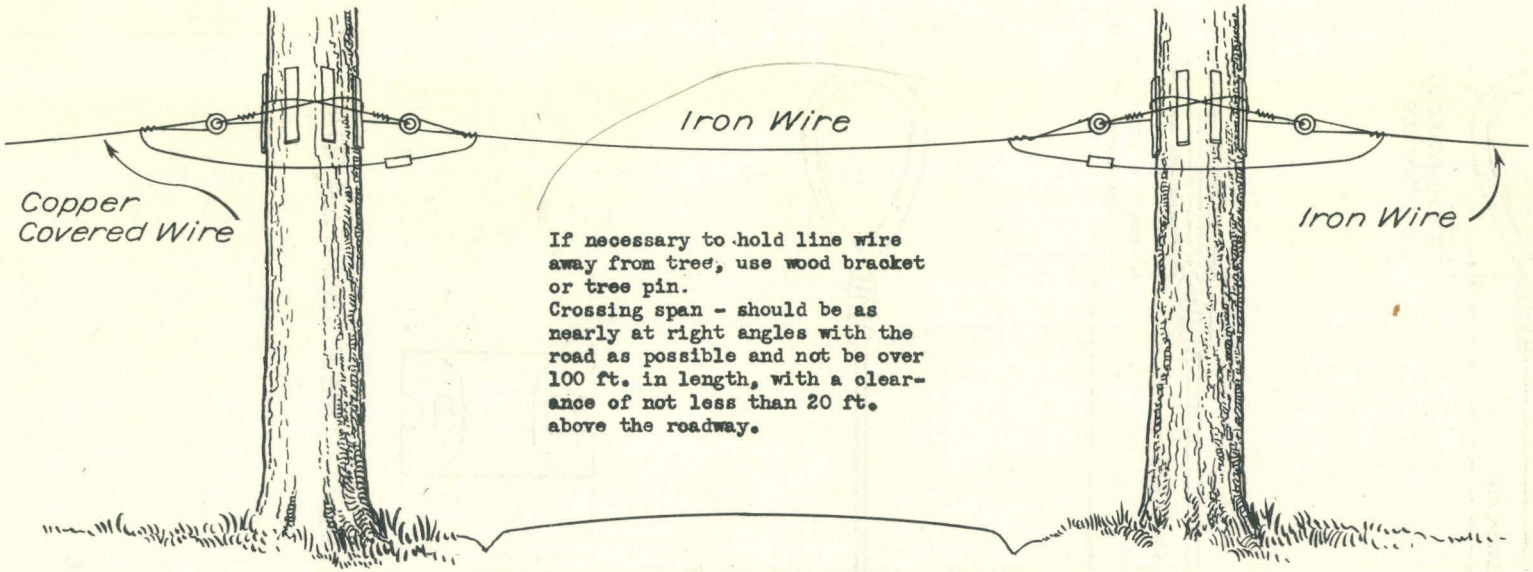
Smooth off rough bark before driving staples, but do not cut into the sap. Ordinarily, tree hooks can be properly driven into the tree without removing the bark. Long hooks should be driven about $2\frac{1}{2}$ inches in solid wood, leaving room for many years of tree growth. On thin bark trees, the hooks frequently can be properly located in the thin part of the bark.

Staples should be driven at a vertical angle to cause the tie to remain against the tree or pole. Staples in trees should be driven in only sufficient to hold, leaving room for many years of tree growth before the staple is overgrown.

21. Slack

Leave sufficient slack in each span so that the line may be easily pulled to the ground between two hangers. "Easily pulled" means that the wire will come down under an applied weight of from 75 to 90 pounds. About 3 or 4 feet of slack is about right for each span ranging in length from 100 to 140 feet. In order to maintain even distribution of slack, spans must be of approximately equal length. When it is necessary to make a long span, for instance, as in crossing a river or ravine, the wire should be dead ended on each side of the long span similar to the method used for making a road crossing shown in Figure 6.

Longer spans will be given more slack. A span of 400 feet should have not less than 10 feet and one of 1,000 feet should have not less than 20 feet. Spans of intermediate lengths should have slack in due proportion.



METHOD OF CROSSING OVER FOREST SERVICE 25 MILE ROAD

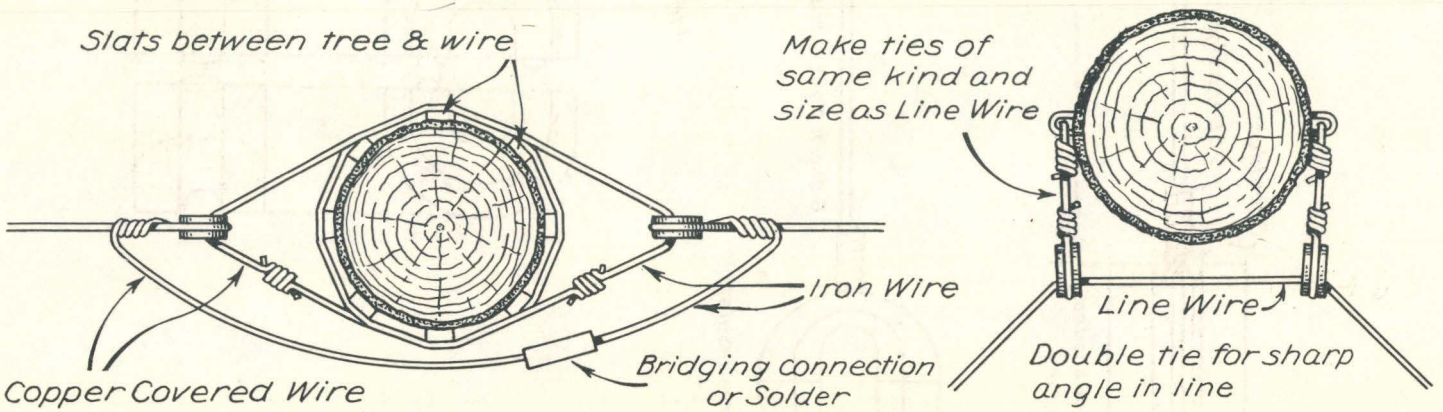
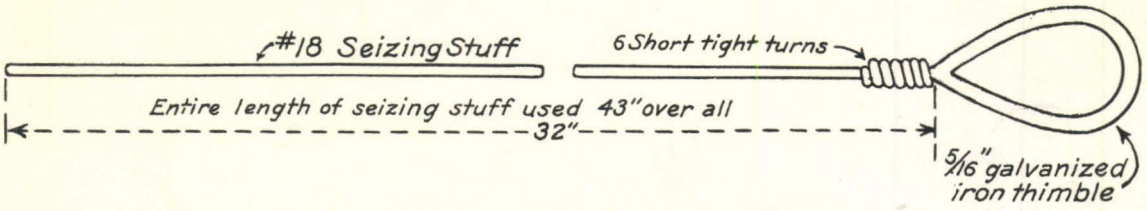
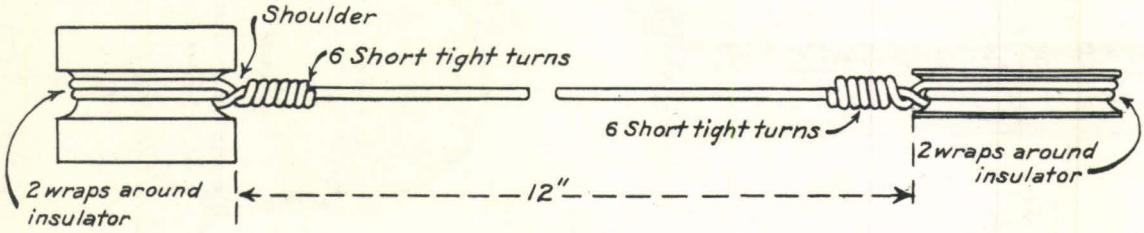
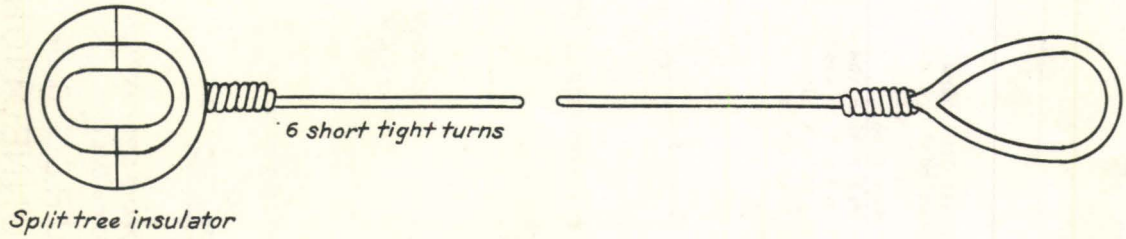


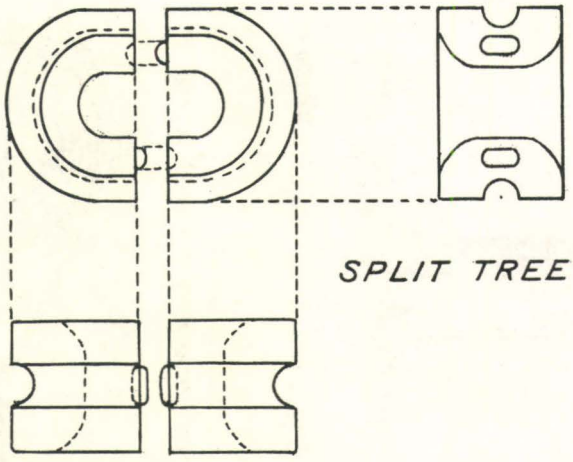
FIGURE 6
LINE CONNECTIONS







HANGERS



SPLIT TREE INSULATOR

FIGURE 7

STANDARD TIES

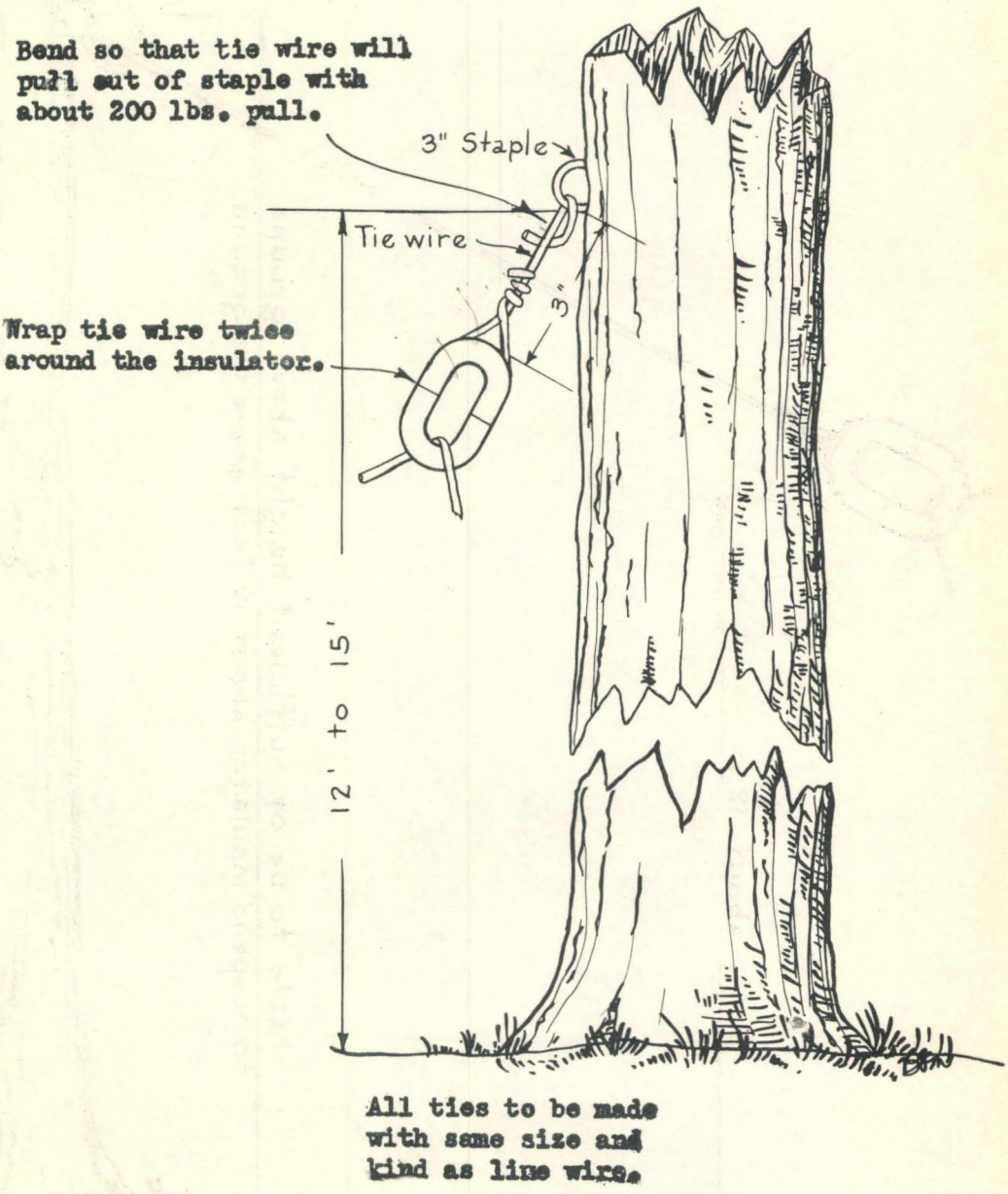


FIGURE 8

STANDARD SHORT TIE

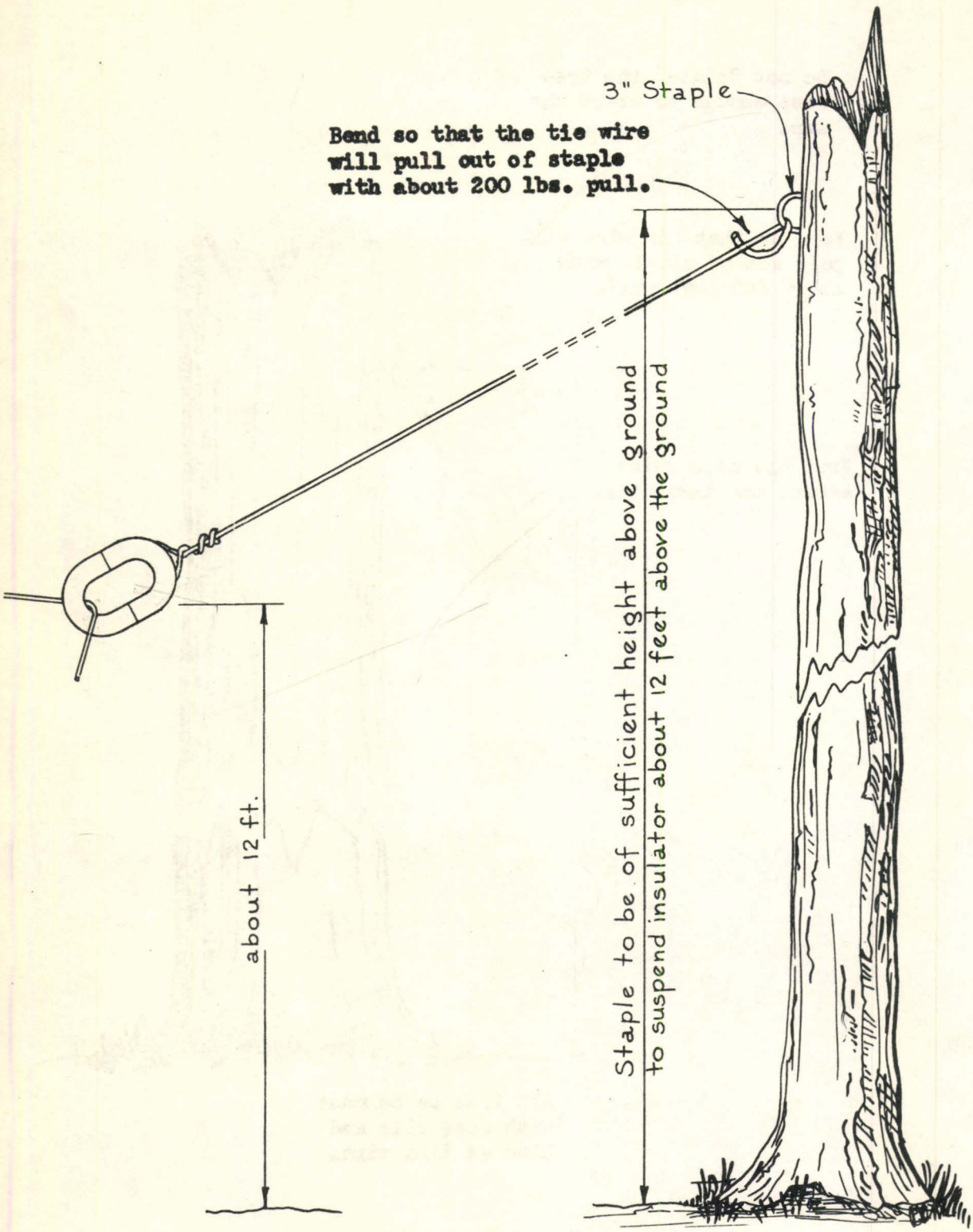


FIGURE 9

STANDARD LONG TIE

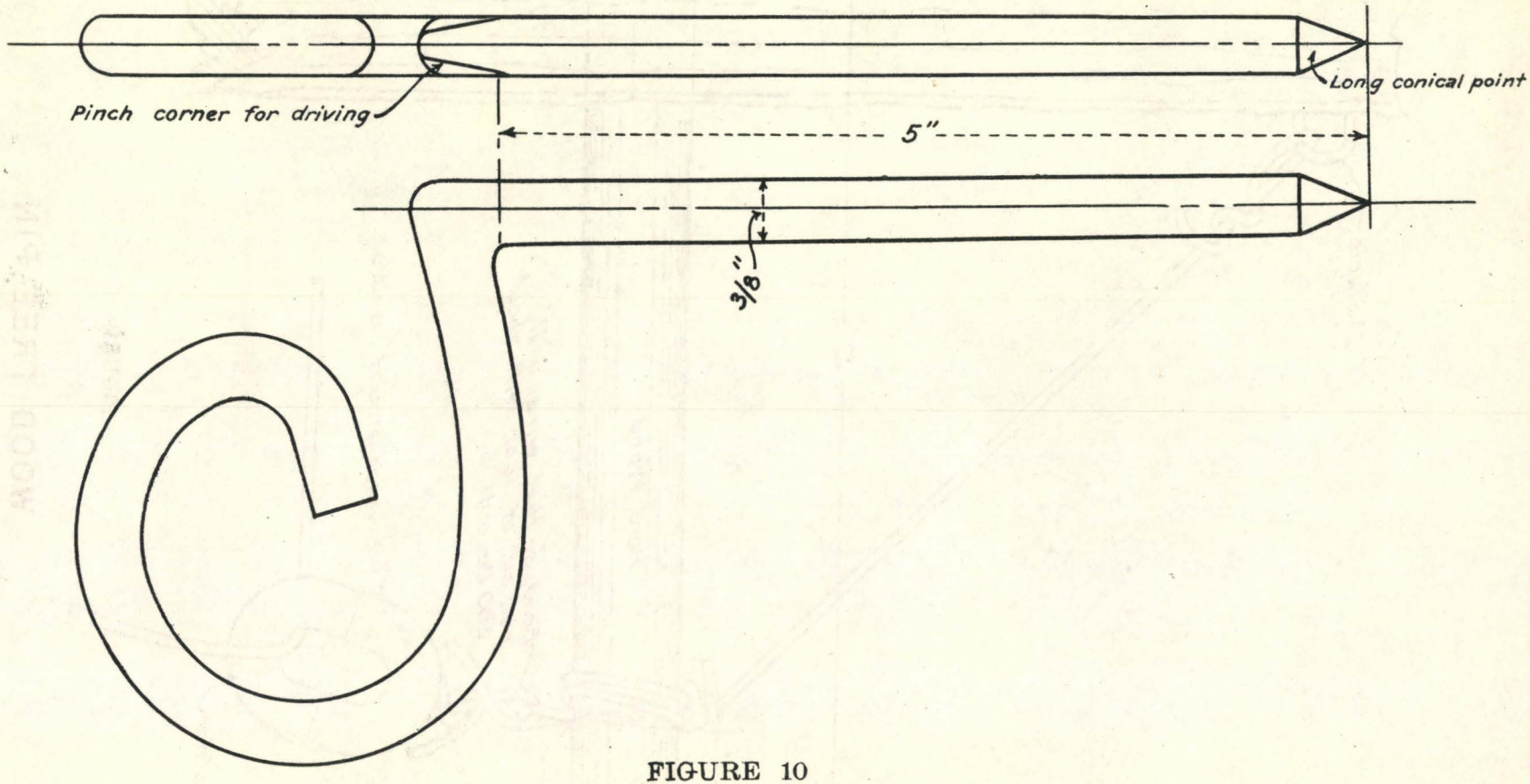


FIGURE 10

TELEPHONE TREE HOOK

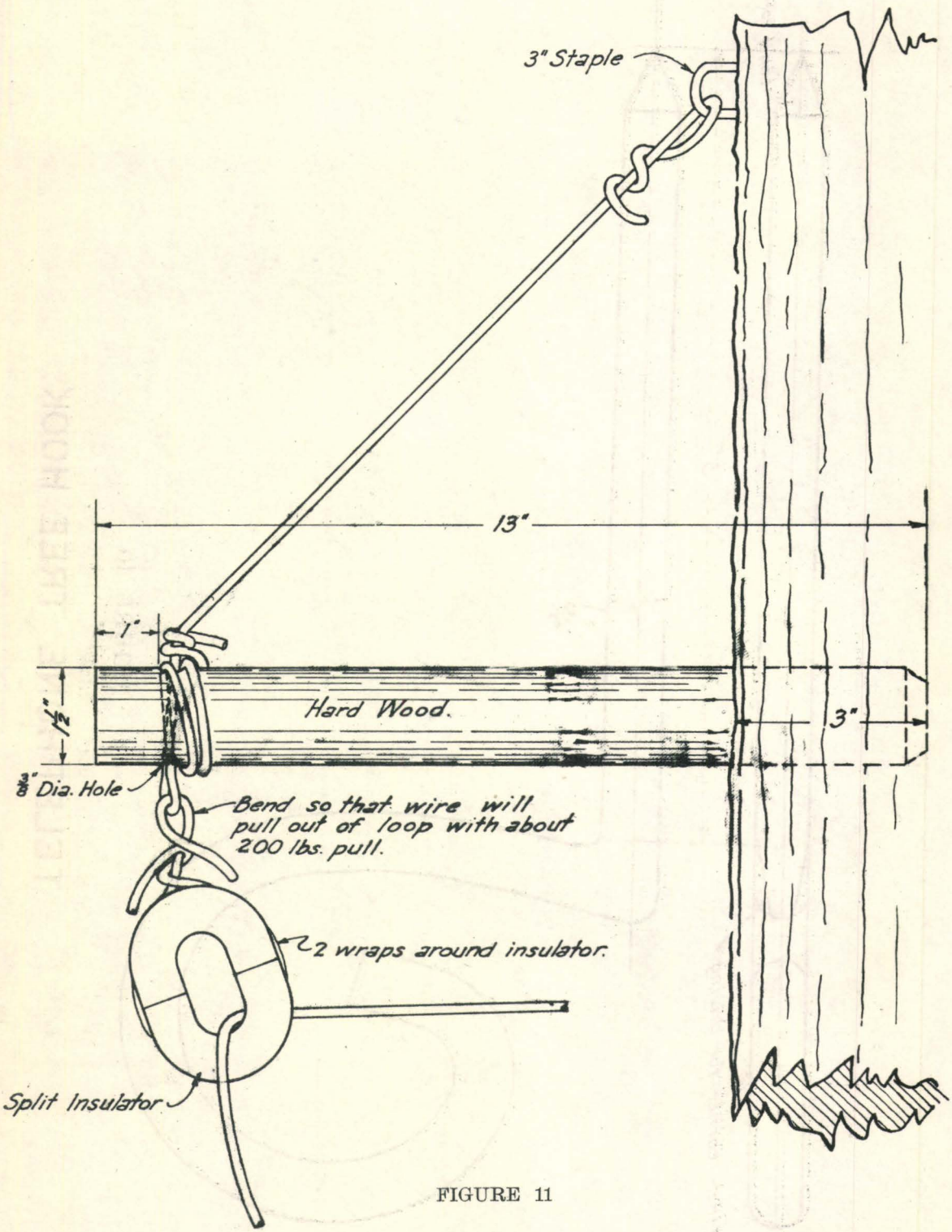


FIGURE 11

WOOD TREE PIN

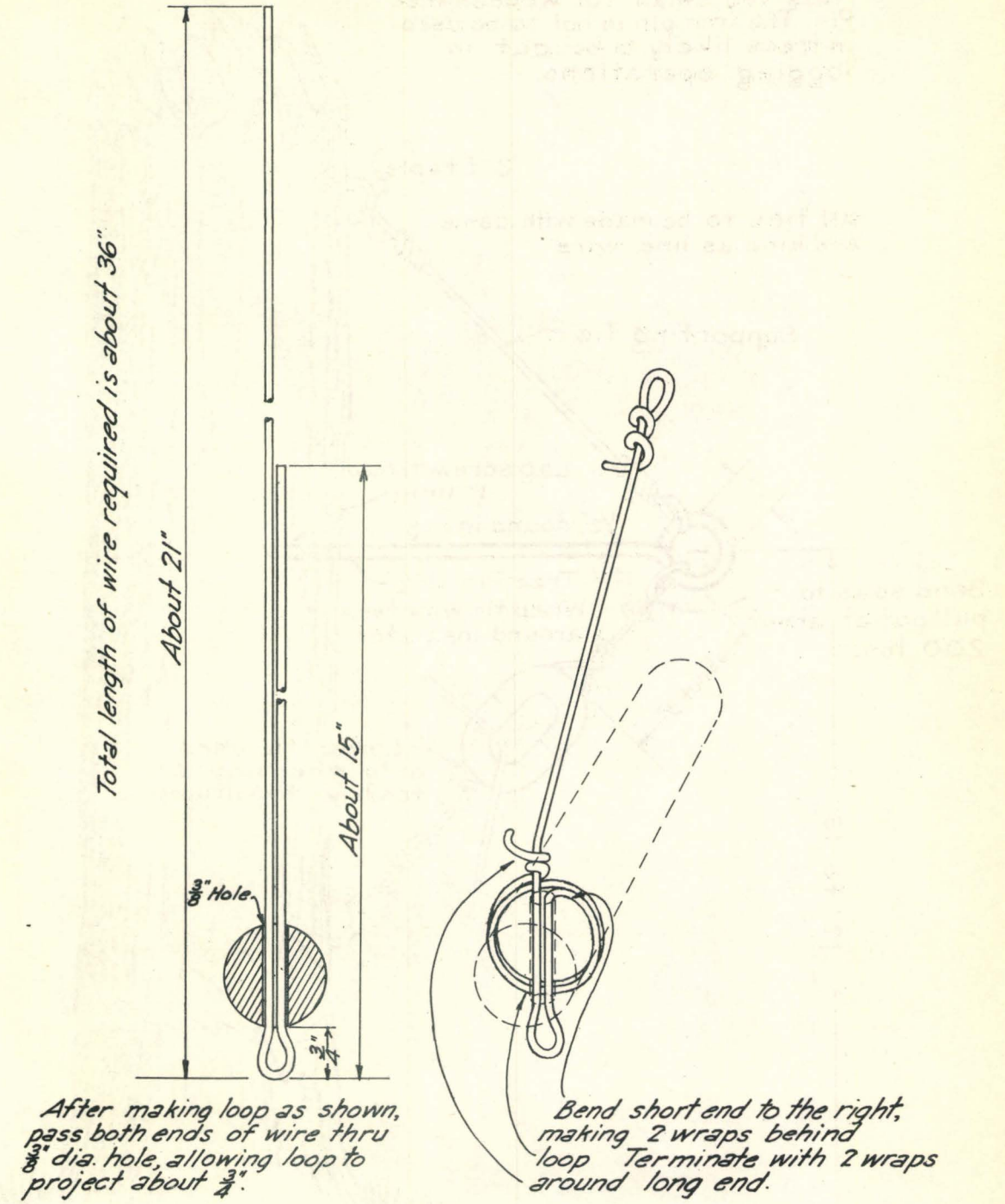


FIGURE 12

METHOD OF MAKING TIE FOR WOOD TREE PIN

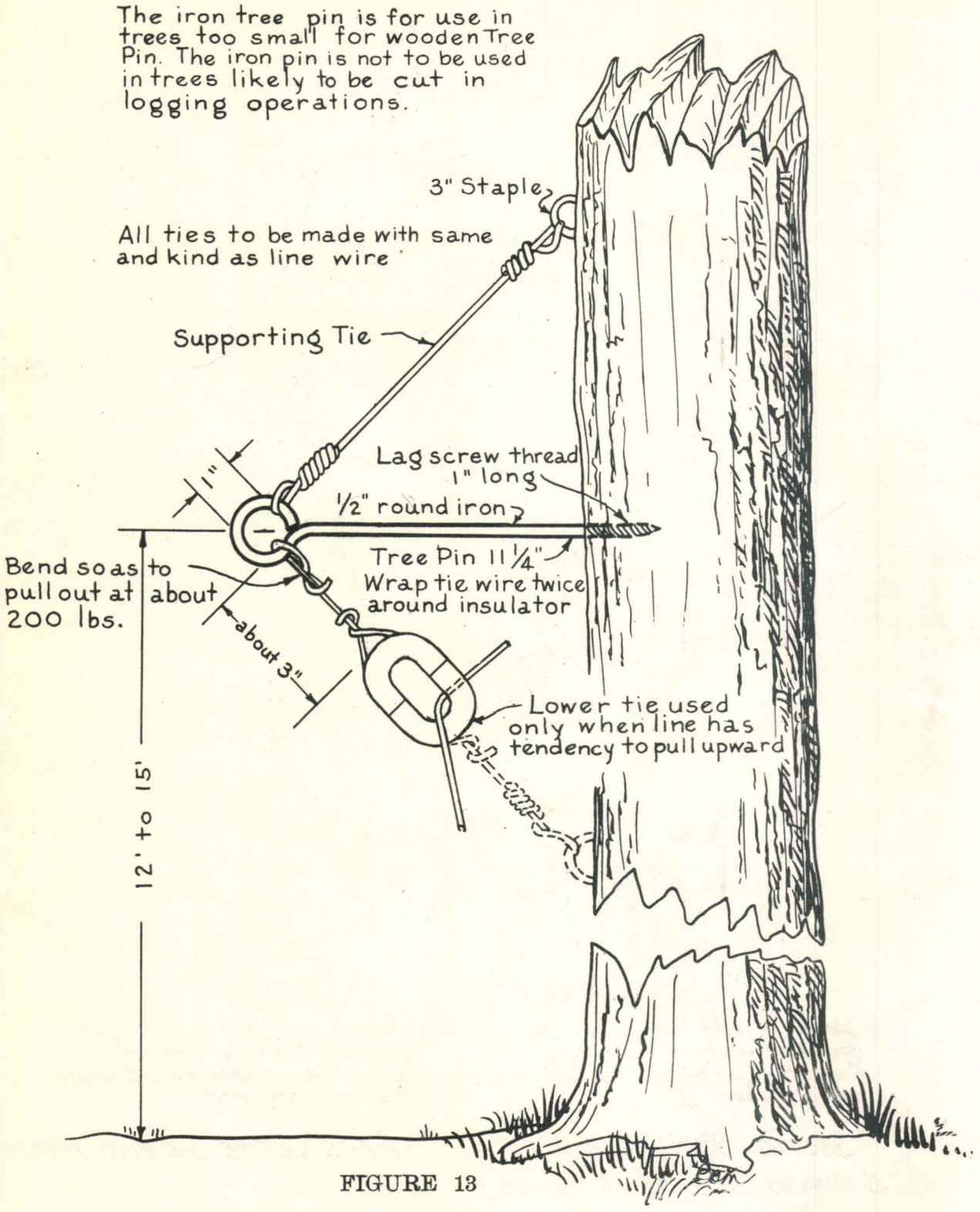


FIGURE 13

IRON TREE PIN

22. Pulling Slack

Do not use blocks and tackle to pull slack for they are unnecessary, except possibly in pulling up long spans across inaccessible places. "Tight lines" can be charged to the use of blocks oftener than to any other cause. Pull up slack by hand at intervals of every sixth or eighth tie, or more frequently. Have someone behind to see that it is up in proper position, that it has plenty of slack and that it is hanging free of all obstacles that may, when removed, call for radical readjustment of the line wire. Hold each pull by the simple device of hitching the wire directly to a limb, tree, or root, or with a lineman's grip and rope, fix the grip on the wire, and tie the rope to some stable object.

23. Final Clearing

With a given section of the line in final and proper position, send a man back over it for the purpose of removing all branches, etc., in order to insure that the clearing specifications are completely met.

24. Brush Disposal

The Regional Forester will establish brush disposal practice appropriate to different conditions or regions. The methods used should not be more costly than is required by demonstrable needs on account of fire danger, and of the aesthetic or scenic values existing along recreational roads. Ordinarily one of the three following methods will be used:

1. No disposal where brush is very light.

2. Lop and scatter where brush is moderate.

3. Pile and burn where brush is heavy.

SECTION V - POLE LINE CONSTRUCTION

25. Location

Pole lines will be built only where:

1. Trees are not available on a feasible and practicable route.

2. It is necessary to construct a metallic circuit to eliminate interference from other telephone or telegraph lines, electric power lines or static.

3. There will be a number of telephone lines along the same route.

26. Scenic Highways

Pole lines should not be constructed on National Park highways unless approved by the Regional Forester.

If approved by the Forest Supervisor, a pole line may be constructed on or along scenic sections of a road or highway, not including National Park highways, provided there is no alternate feasible route and if consistent with local or state policy. When it is necessary to use the highway right of way, the poles should be set on the side away from scenic points of interest; such as a stream or lake, a view from the road through a clearing in the timber or along the side of a mountain, etc.

Only poles which are symmetrical, reasonably straight and peeled should be used - without crossarms unless there are more than four wires. There should be no overhead guys crossing the roadway unless absolutely necessary. Very often, if oversized poles, set with a rake, are used on curves, no guys will be required. If there are trees along the highway, it may be desirable to set the poles back in, or close to the edge of the timber; or to make them more inconspicuous by spraying the poles and crossarms with a suitable color, which should be selected by a qualified person and may vary in accordance with cover and surroundings. In general the pole line should be made as inconspicuous as possible.

Care should be taken not to leave any brush scattered on the ground where it will be conspicuous or where it will increase the fire hazard.

27. Pole Line Classifications

Primary pole lines include these carrying a trunk or branch circuit, or circuits, necessary for fire control or administrative purposes over which a high standard of communication, with a minimum of interference and trouble, is required.

Secondary pole lines include these carrying ordinarily not more than two circuits which are of secondary importance and used principally for administrative or recreational purposes over which reasonably dependable communication is required.

28. Location of Poles on Road or Highway

Ordinarily poles should be set from 3 to 5 feet inside the road or highway right-of-way, unless otherwise specified by the county court or State Highway Commission. In the event it is necessary to set poles closer to the traveled part of the right-of-way, care must be taken to see that poles are not in the way of road maintenance equipment, etc. Poles should be set so that on curves the line will not hang over the traveled part of the right-of-way. Poles should not be set across private right-of-ways without first securing easements or written permission.

29. Classes of Construction

There will be three classes of construction A, B and C.

Class A constrution will be used either for pole lines built along important arterial highways, through municipalities, or those carrying important circuits. The species and preservative treatment of the poles used will follow the best commercial practice necessary to insure a minimum pole life of 20 years. This class of construction will not be followed unless approved by the Regional Forester.

Class B construction will be used for the average Forest Service pole lines unless otherwise specified by the Regional Forester. Poles and preservative treatment, if any, will be selected to insure a minimum life of 10 years.

Class C construction will include either round or split poles, stubbed poles, tripods, other special construction, etc. This class of construction may be used on forest ways, trails, "across country", etc., along routes not classed as scenic; but should not be used through municipalities or settlements. Stubbed poles, if the stubbing is properly done, cost as much, and often more, than full length poles and their maintenance cost is usually considerably higher. Therefore,

this method of construction should be used only in isolated regions where the transportation costs of full length poles would be excessive.

30. Pole Line Specifications

Covering Poles, and Pole Treatment

The following specifications and instructions will be used for the construction of pole lines, except where, on account of peculiarity of conditions, it is impractical to secure pole and crossarm material of appropriate species and dimensions. In this event poles, crossarms, etc., of other species and dimensions, may be substituted upon approval of the Regional Forester.

Class A Construction

1. Pole Species and Treatment: Western red cedar, Northern white cedar, lodgepole pine or chestnut complying with A.S.A. specification 05c1 and 05c2 to be butt treated with creosote according to A.T.&T. specification 6240. If the cost is the same or lower, the poles may be of Southern yellow pine, Norway pine, Ponderosa pine, Western larch or Douglas fir complying with A.S.A. specification 05g1 and 05g2 framed according to figure 19 and have a full length 8 pound empty cell treatment of creosote according to A.W.P.A. specification 41A.

2. Pole Sizes: All poles should ordinarily be class 6 with a minimum circumference 6 feet from the butt equal to 24 inches, and a minimum top circumference of 17 inches. This size of pole will withstand a pull of 1500 lbs. applied 2 feet from the top. This is the commercial standard size for poles carrying 8 wires or less.

3. Pole Lengths: Ordinarily to be 25 feet, and longer if necessary to secure a minimum clearance between the lowest wire and the ground of 20 feet at intersections or driveway crossings - more if required by state laws. Twenty foot poles may be used along less important highways and through sparsely settled areas. The lowest wire along a highway must have a minimum clearance above the ground of at least 15 feet.

Class B Construction

1. Pole Species and Treatment: Poles which comply with the specifications for Class A construction may be used if obtainable at a reasonable cost. Any other species may be used with or without treatment, if local experience has demonstrated that it will have the average life required. Poles must be of sound timber and reasonably straight, cut locally as near the job as possible. Thoroughly seasoned lodgepole pine poles conforming to A.S.A. specification 05f1 and 05f2 - 1933 with a full length 8 pound empty cell creosote treatment at a commercial plant or butt treated with creosote at a Forest Service treating plant may be used. See figure 15.

2. Pole Sizes: All poles should ordinarily be Class 7 with a minimum circumference 6 feet from the butt equal to 22 inches and a minimum top circumference of 15 inches.

3. Pole Lengths: Ordinarily to be 25 feet and longer if necessary to secure a minimum clearance between the lowest wire and the ground of 20 feet at intersections or driveway crossings - more if required by state laws. Twenty foot poles may be used along less important highways and through sparsely settled areas. The lowest wire along a highway must have a minimum clearance above the ground of at least 15 feet.

Class C Construction

A. Full length Poles Round or Split
   1. Pole Species and Treatment; To be the same as for Class B construction.
   2. Pole Sizes: To be the same as for Class B Construction.
   3. Pole Lengths: 18 to 20 feet permitted provided they will give ample clearance above ground.

B. Stubbed Poles
   1. Stubs Species and Treatment: Western red cedar, Northern white cedar, yew or juniper, and the Heartwood of redwood, Southern cypress and chestnut may be set untreated. Lodgepole pine, Douglas fir and Western larch must be treated with creosote as specified for Class B Construction.

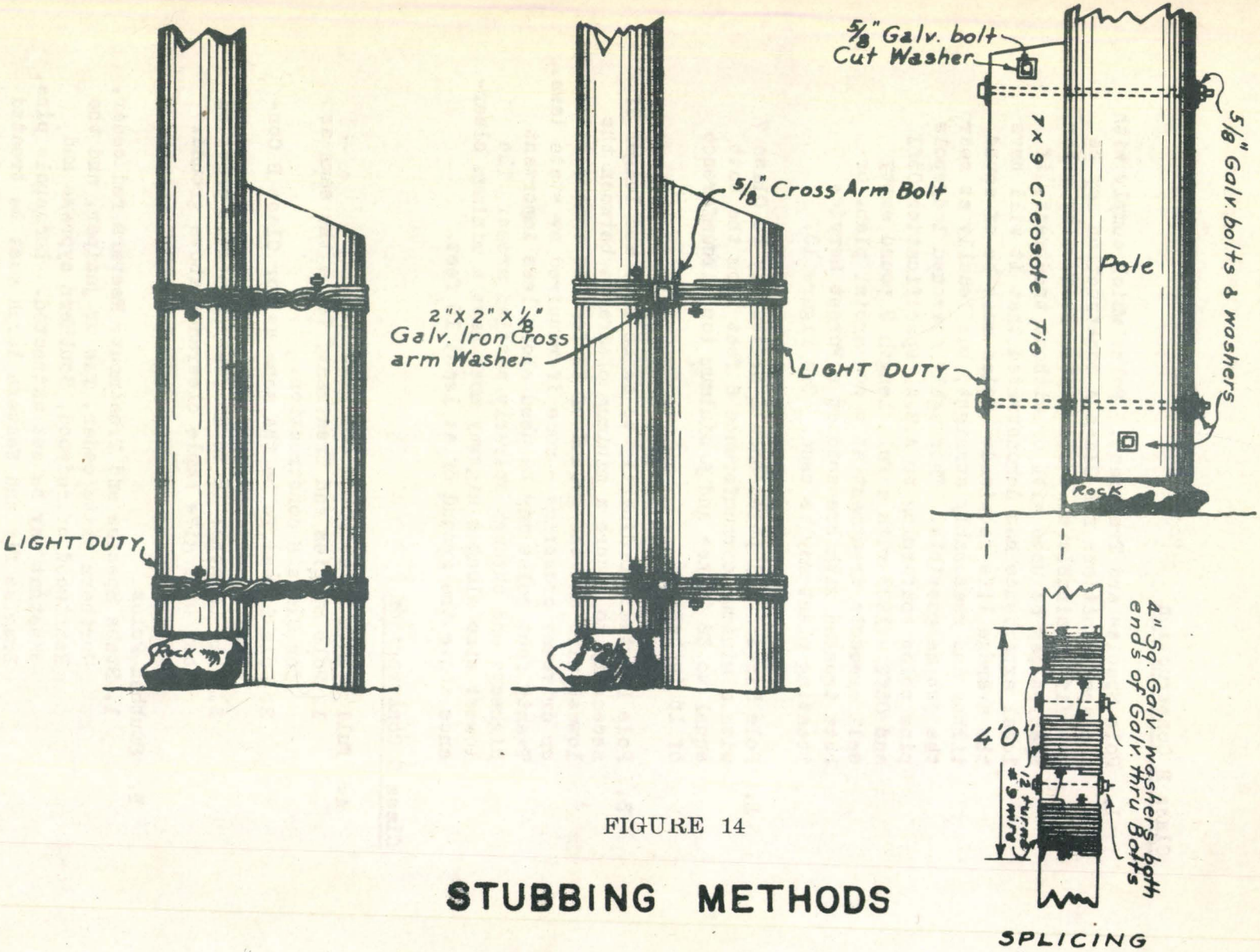


FIGURE 14

STUBBING METHODS

2. Stubs Lengths and Sizes:

Western red Cedar	-	length	8'	min.	circum.	5'	from	butt	30"
No. white Cedar	-	"	8'	"	"	5'	"	"	30"
Redwood	-	"	8'	"	"	5'	"	"	30"
Chestnut	-	"	8'	"	"	5'	"	"	30"
Southern cypress	-	"	8'	"	"	5'	"	"	30"
Yew	-	"	8'	"	"	5'	"	"	28"
Juniper	-	"	8'	"	"	5'	"	"	28"
Douglas Fir	-	"	8'	"	"	5'	"	"	28"
Lodgepole pine	-	"	8'	"	"	5'	"	"	31"
Western Larch	-	"	8'	"	"	5'	"	"	31"

C. Poles Attached to Stubs

1. Species: Lodgepole pine, fir or larch.
2. Sizes: Round, square or split equivalent to a 6" top diameter round pole.
3. Lengths: Fourteen to sixteen feet or long enough to secure a clearance as specified under Class A pole lengths.

Suggestions for methods of attaching poles to stubs will be found on figure 14. Poles to be attached to stubs preferable on the road side of the stub.

Suggestions covering use and construction of tripods will be found in figure 5.

31. Creosote Treatment of Poles at Forest Service plants

A. General

The timber should be sound, entirely free from decay except as permitted in the A.S.A. specification for poles, carefully peeled, and thoroughly seasoned. In good seasoning weather open-piled poles will take from 5 months to a year; Douglas fir, 5 to 8 months; lodgepole pine and ponderosa pine, 5 to 7 months; western red cedar, northern white cedar and western larch, 8 to 12 months.

B. Preservative to be Used

The preservative should conform to A.W.P.A. specification 4f or subsequent revision.

C. Single Tank Method

With this method only one tank is used. The creosote should be heated to about 200 degrees F. Add additional creosote to the tank to compensate for that absorbed by the wood and lost by volatilization. The material may be placed in the creosote after it is brought to the desired temperature, or at the time heating is begun. At the end of the heating period (from 3 to 7 hours), the fire is allowed to die down or is drawn. The timber is then allowed to remain in the cooling creosote from 3 to 14 hours, depending on the species to be treated. (See following table)

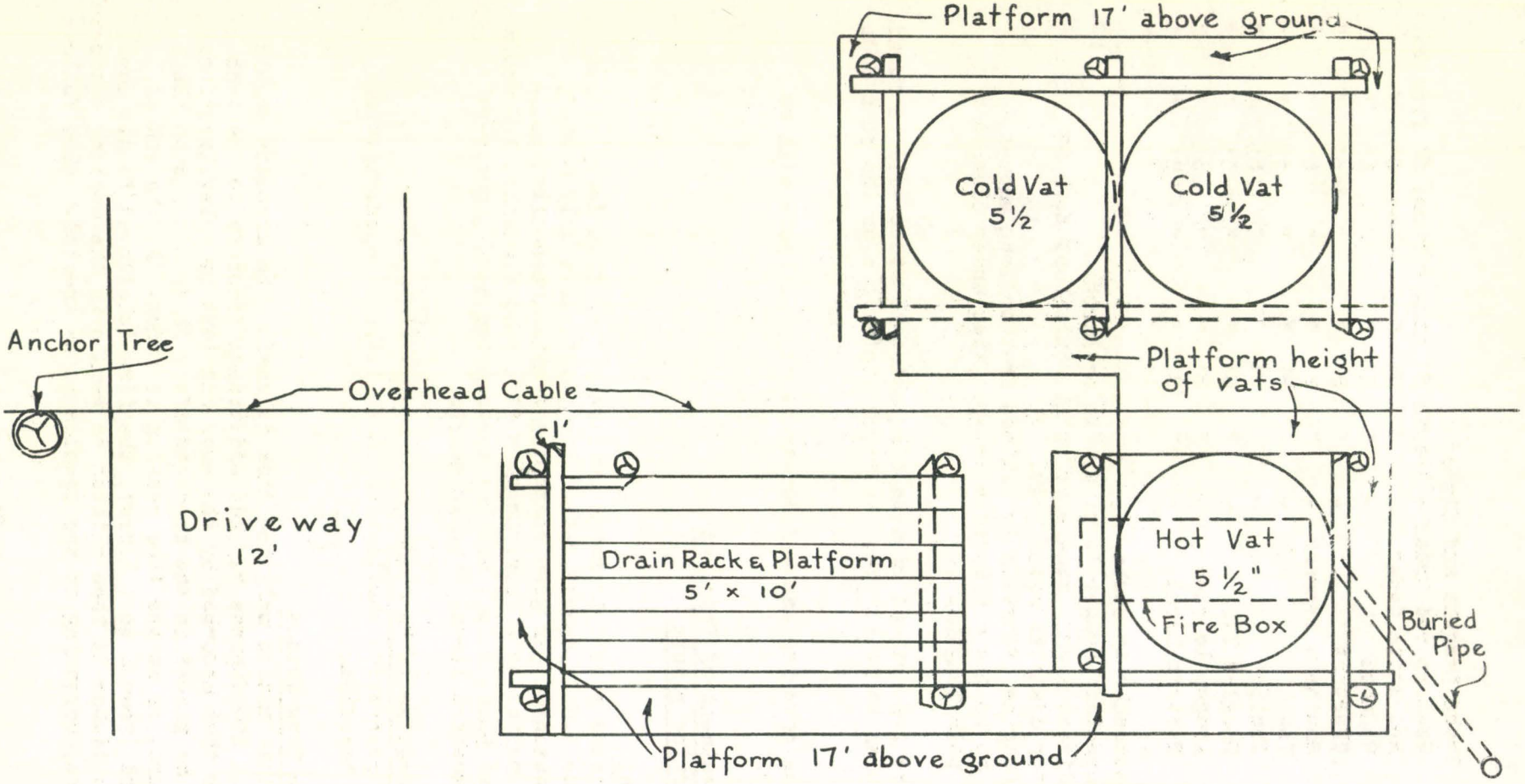


FIGURE 15

PLAN FOR CREOSOTE TREATING PLANT

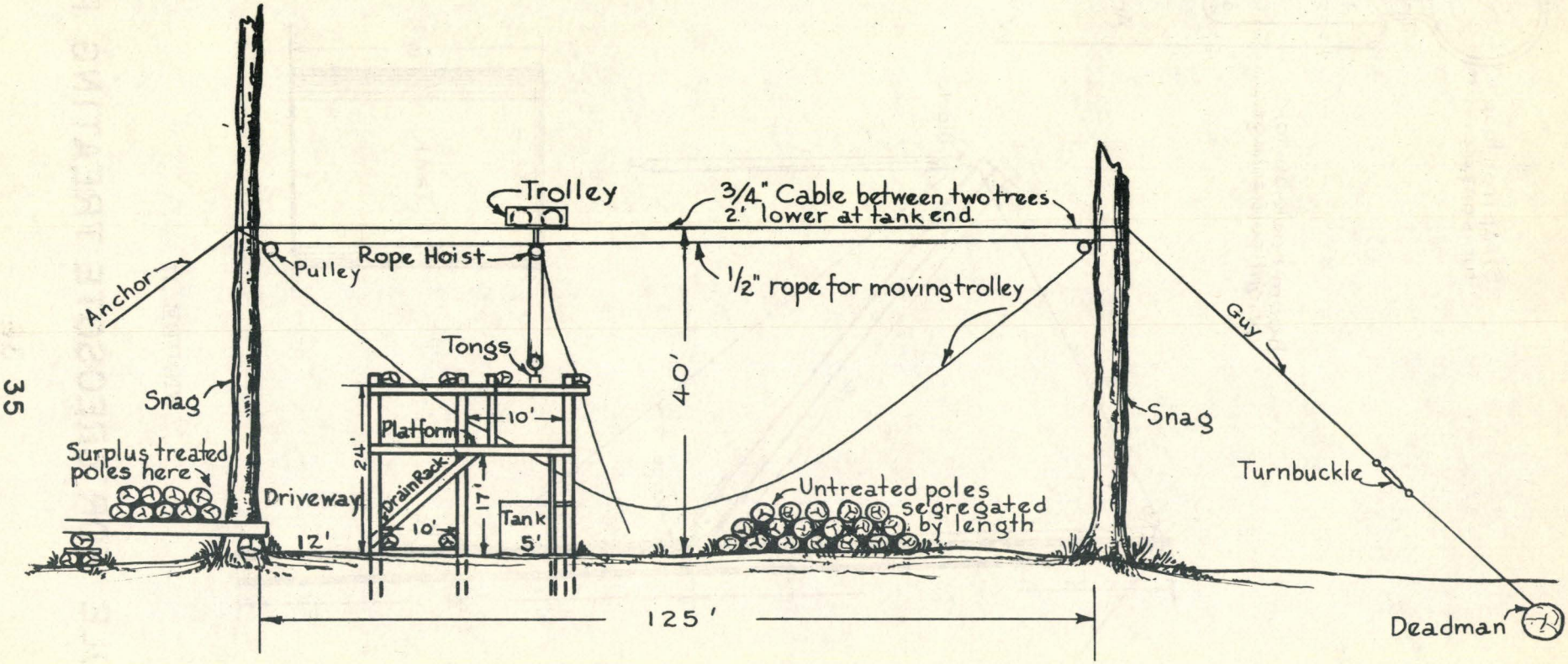


FIGURE 16

SIDE VIEW OF CREOSOTE TREATMENT PLANT

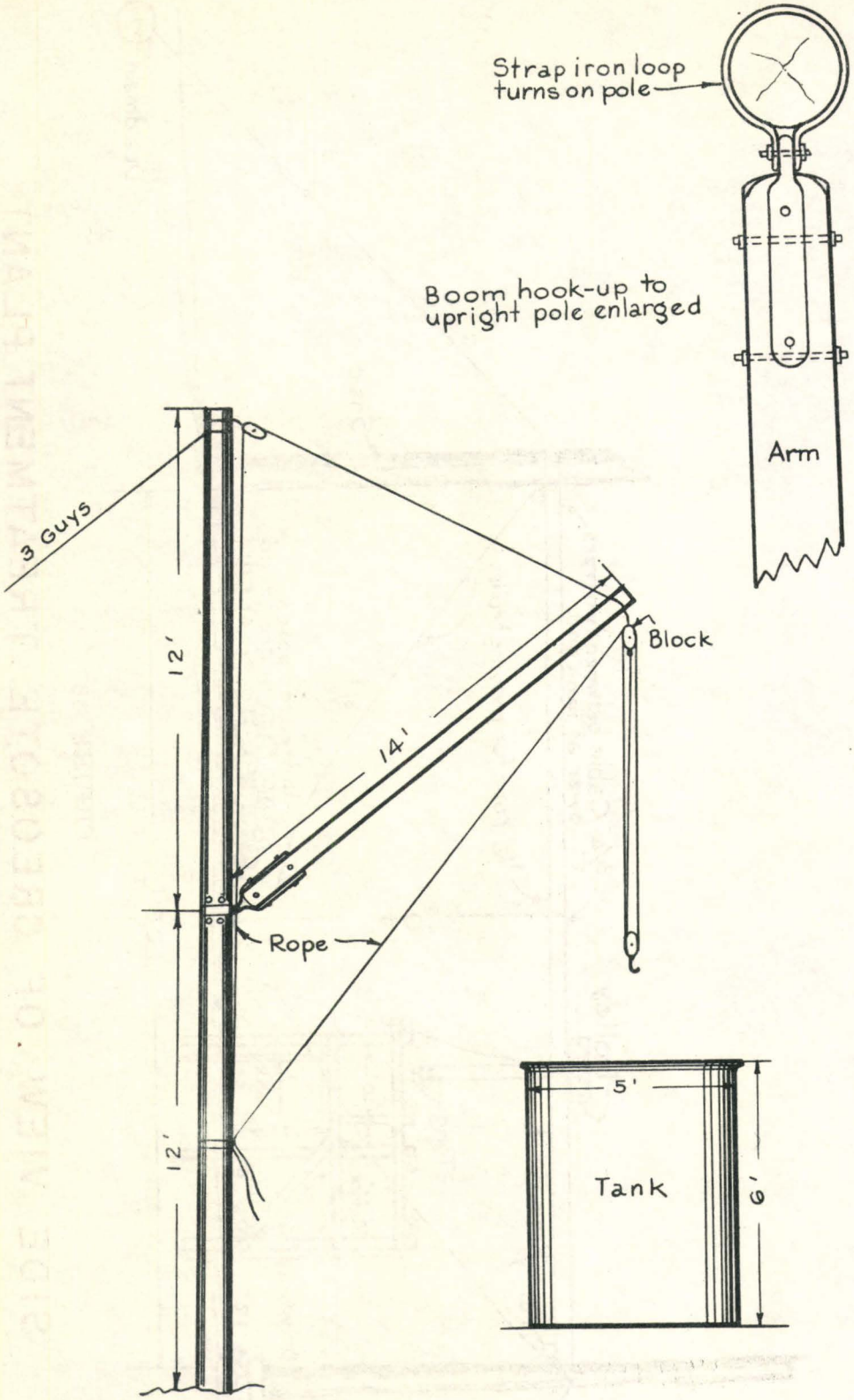


FIGURE 17

GIN POLE FOR CREOSOTE TREATING PLANT

Care should be exercised that the creosote in the tank remains at about the same level, so that a penetration will always be secured for the required length. Treatment should extend at least 1 foot above ground line. The poles should then be removed from the tank and allowed to drain. The surface creosote will drain off the poles better if the oil in the cooling tank is slightly heated prior to the removal of the poles. See Figures 15, 16 and 17 for suggestions for design of plant.

D. Results to be Secured

Penetration ranging from about $\frac{3}{4}$ to 1 inch for lodgepole pine and ponderosa pine, and from $\frac{1}{2}$ to $\frac{3}{4}$ inch for Douglas fir and cedar should give good results. The time necessary to secure any desired penetration will vary with the species, the moisture content of the material, and many other factors, and must be determined by actual tests in each case.

At least one piece of timber from each of the first six runs should be selected for tests.

Penetration tests are best made by boring with an increment borer and then splitting open the boring. In freshly treated poles, a borer sometimes carries oil over the surface of the boring and often indicates a deeper penetration than is actually the case. By splitting the boring, the true penetration can be observed. The hole must be plugged tightly with a creosoted wooden plug.

The following table gives the length of time the poles should usually be left in the hot and cold creosote. The times may be changed, however, as local observations indicate desirable.

Species	Number of hours in hot creosote	Number of hours in cooling creosote
Lodgepole pine (cut green and seasoned)	7	14
Lodgepole pine (fire killed)	3	7
Ponderosa pine	4	3
Douglas fir	7	14
Western red cedar	7	14
Spruce	7	14

The best treatment is the one which gives the greatest penetration with the least absorption of oil. The hot oil bath controls the penetration. If the penetration is not sufficient, the hot bath should be lengthened. If the penetration is satisfactory but too much oil is absorbed, the cold or cooling bath should be shortened. The schedule given should produce an absorption of from 4 to 8 pounds of oil per cubic foot of wood impregnated. In the experimental work, which has been

conducted on lodgepole pine in Region One, with similar time schedules the 6 inch by 25 foot poles absorbed about 1.5 gallons of oil for each pole. In using these figures in estimating the amount of oil required for a given job, allow from 10 to 20 per cent additional for evaporation during treatment.

Low residue oil is extremely volatile, and to reduce volatilization of oil, the hot bath should be given at as low a temperature as possible, without impairing the treatment. In specifying 200 degrees F, for the hot bath, it is assumed that the timber is thoroughly air-dry. The maximum temperature should not be allowed to go above 220 degrees, as excessive heating is likely to unduly increase the loss of the oil through volatilization. There is also danger that the oil will boil over the sides of the tank and take fire when an open flame is used. The oil is not dangerously inflammable, but treating plants should not be constructed near to buildings or other valuable property.

32. General Instructions for Pole Line Construction

A. Lightning Conductors

The present trend in commercial practice is to discontinue the use of lightning conductors except in localities of extremely high lightning hazards. Even in these localities the conductors are placed only on every fifth to tenth pole.

The practice now is to have the lower end of the conductor stop 4 feet above the ground line. This keeps the line from being normally grounded and is recommended as a safety measure by preventing the men from being accidentally connected to the ground, when working on the line. Stopping the conductor above the ground line will not keep lightning from jumping to the ground. See Figure 18.

B. Framing

All poles are to be framed before treatment, according to the best commercial standards. Recommended framing is shown in Figure 19.

C. Brackets

Brackets may be used for poles on which there will not be more than four wires, provided there will be a sufficient clearance between the lowest wire and the ground. Brackets should be attached to the poles as shown in Figure 20. When necessary in order to secure proper clearance above the ground either at intersections or along the side of the road, the brackets for both wires of a metallic circuit may be attached to the pole at the same height from the ground as shown in Figure 21. Transpositions of lines on brackets will be more effective in securing a balanced circuit with the wires in this position, than if placed one above the other.

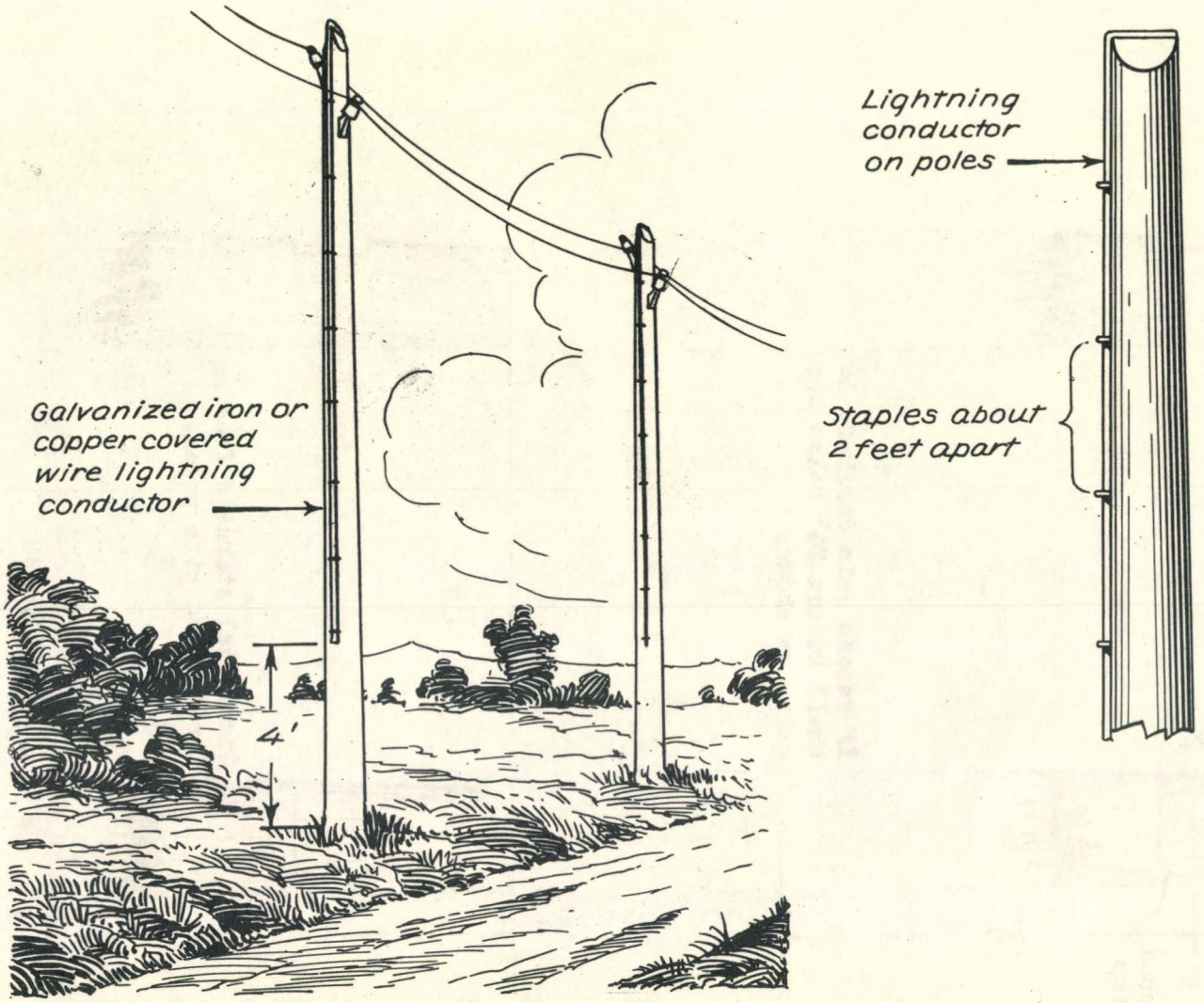
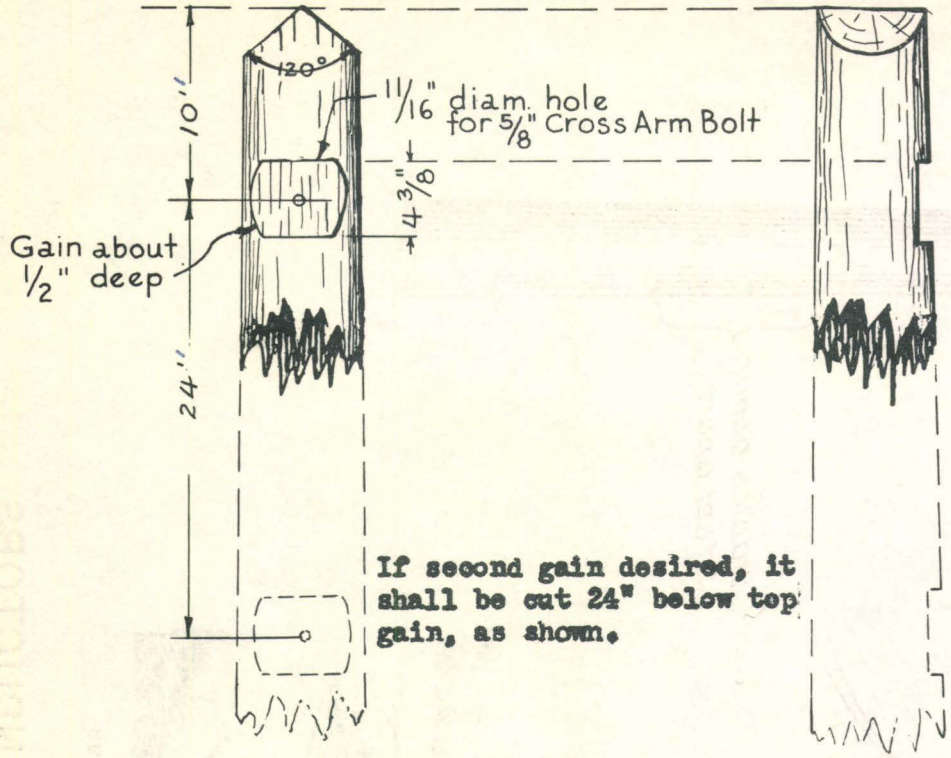


FIGURE 18

LIGHTNING CONDUCTORS



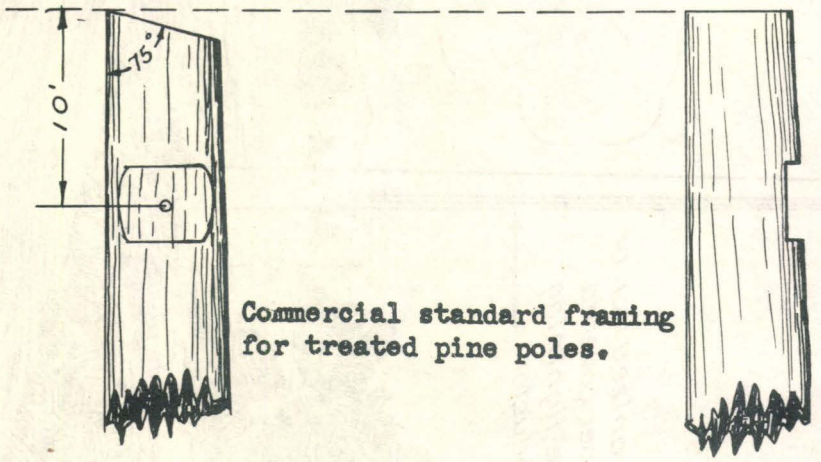


FIGURE 19

STANDARD FRAMING

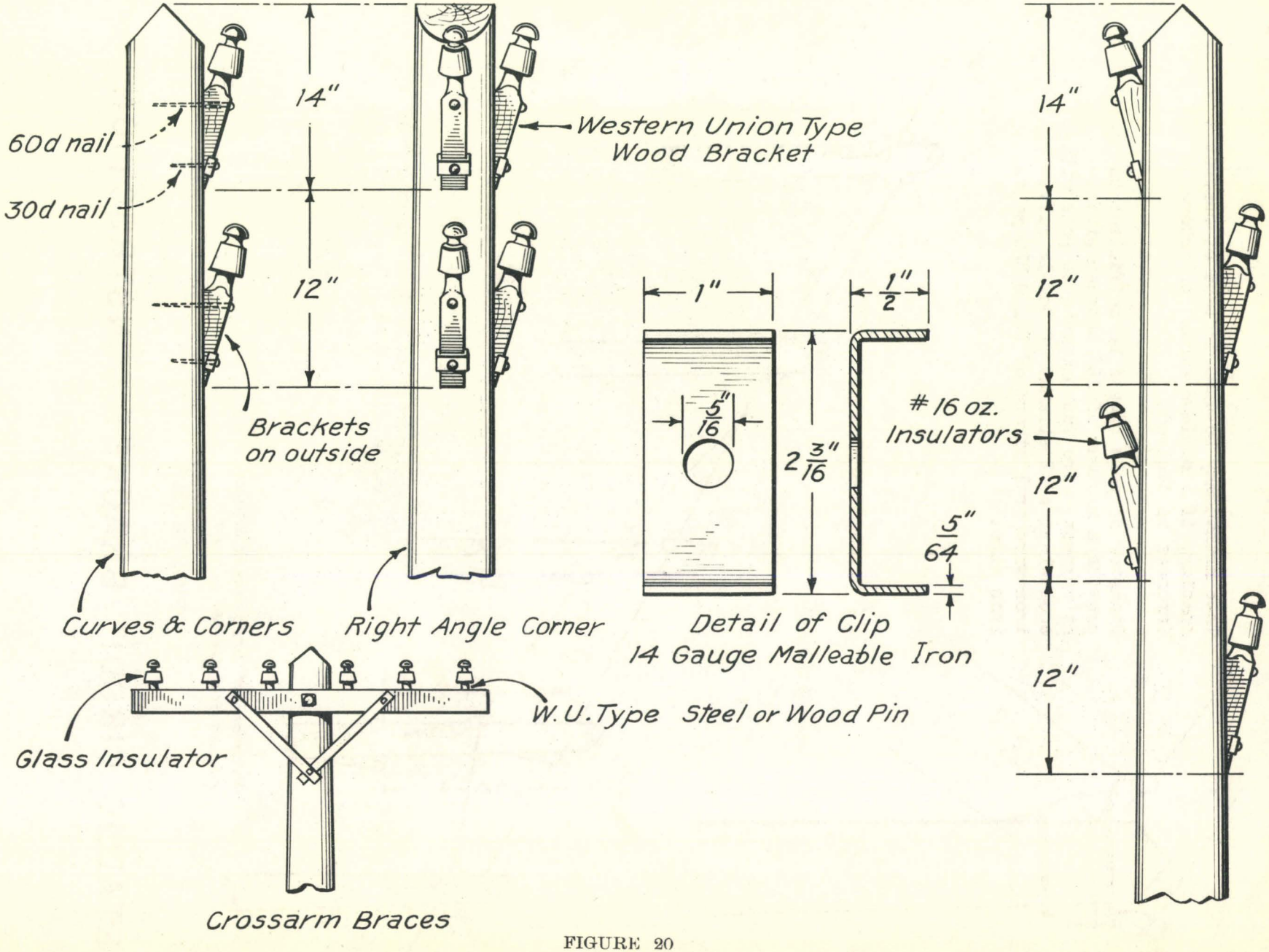
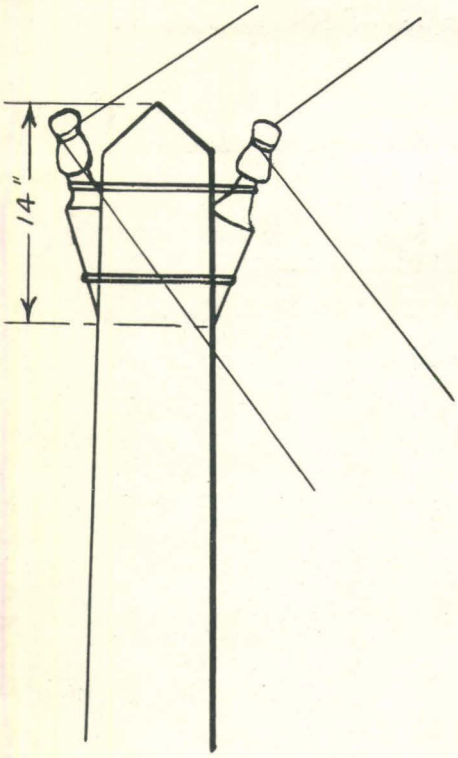


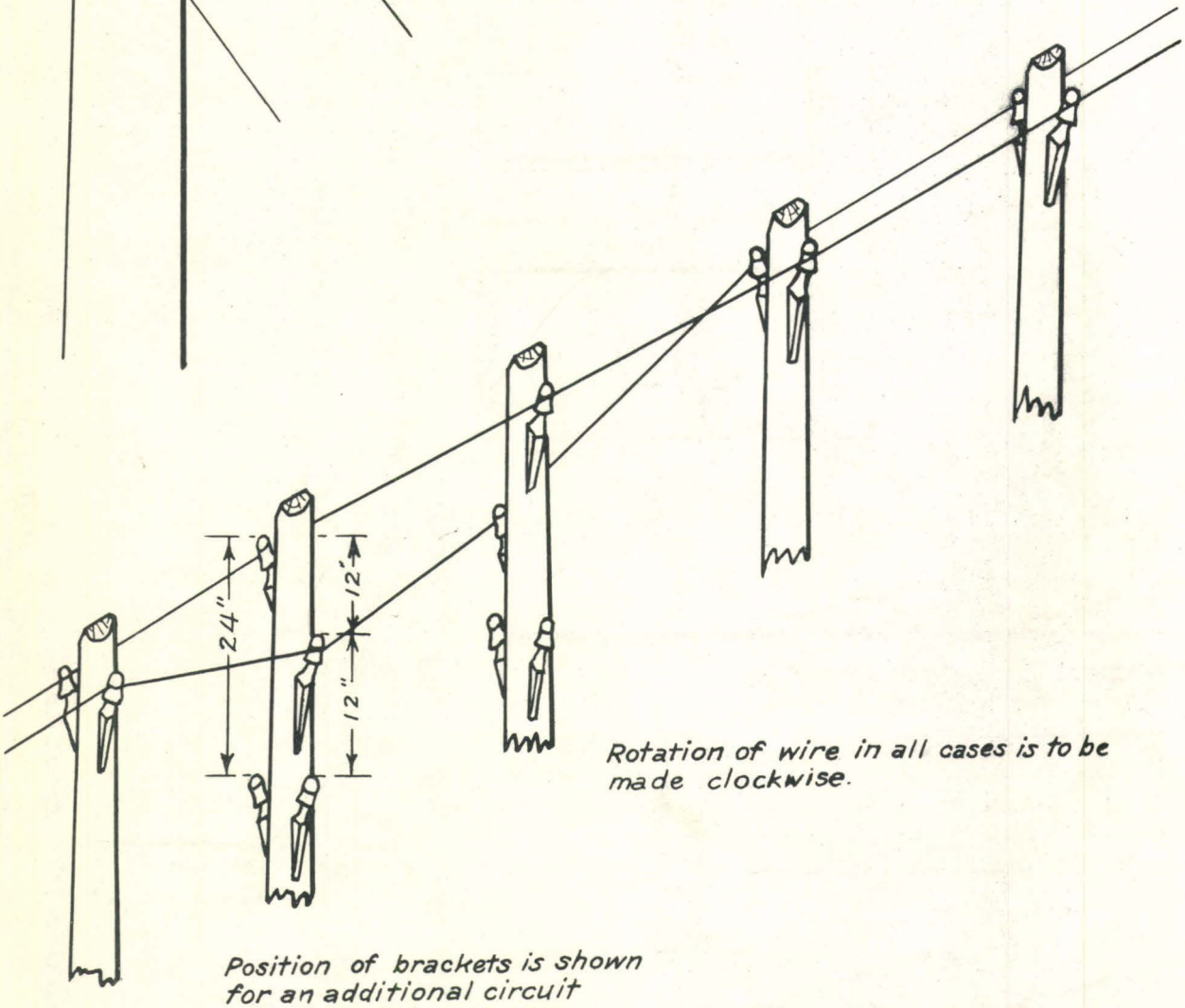
FIGURE 20

METHOD OF ATTACHING BRACKETS



This method may be used instead of bracket spacing, if a minimum amount of interferences is desired.

Diameter of pole should be sufficient to provide a minimum of 10" between wires. At corners, wire the brackets to pole with equivalent of 2 strands of No. 12 galv. iron wire or 1 strand of No. 9 BWG galv. iron wire.



Rotation of wire in all cases is to be made clockwise.

Position of brackets is shown for an additional circuit

FIGURE 21

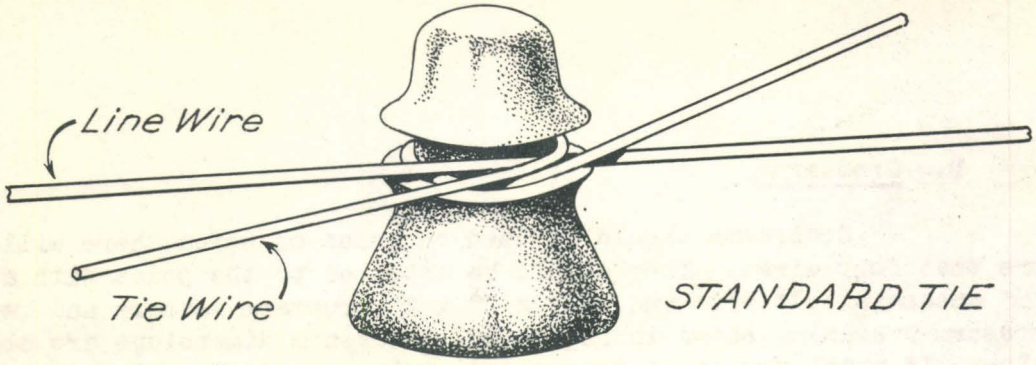
METALLIC CIRCUIT BRACKET CONSTRUCTION

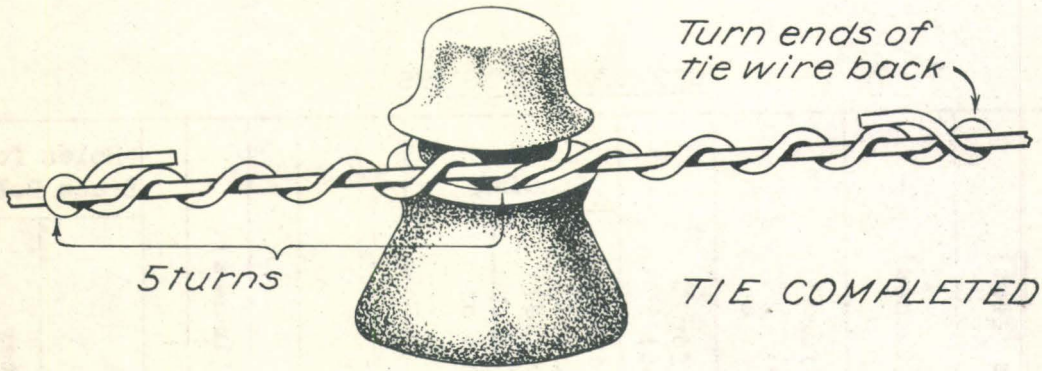
D. Crossarms

Crossarms should be used on poles on which there will be more than four wires. They should be attached to the poles with a 5/8" crossarm bolt with two 1/8" x 2" x 2" crossarm washers and two crossarm braces as shown in figure 20. Crossarm dimensions are shown below. If poles are to be crossarmed, gains are to be cut and the holes bored as shown in Figure 19.

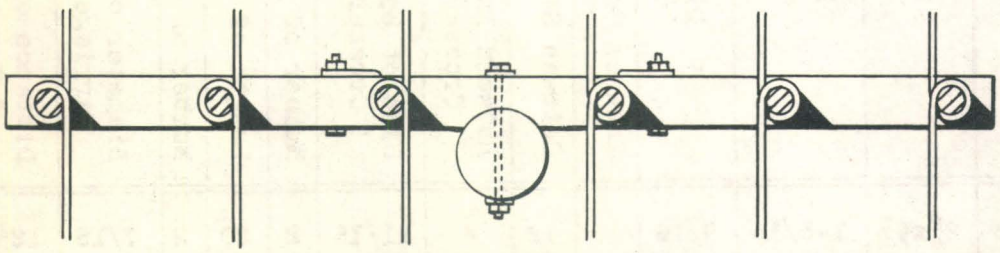
CROSSARM DIMENSIONS

Number of Pins	Length of Crossarm (feet)	Size of Crossarm (inches)	Diameter of holes for wood pins (inches)	Diameter of holes for steel pins (inches)	Pin Spacing			Size of bolt hole in center of Crossarm (inches)	Number of Crossarm braces	Length of Crossarm braces (inches)	Number of holes	Holes for Brace Bolts	
					Between Center Pin Holes (inches)	Between Side Pin Holes (inches)	Between End Pin Hole and End of Crossarm (inches)					Diameter of Holes for 3/8" carriage bolts (inches	Distance of Holes from Center of Crossarms (inches)
6	6	$2\frac{3}{4}$x$4\frac{1}{4}$	1-5/16	9/16	16	12	4	11/16	2	20	2	7/16	$12\frac{1}{2}$
10	10	$3\frac{1}{4}$x$4\frac{1}{4}$	1-5/16	9/16	16	12	4	11/16	2	30	2	7/16	21






TIE COMPLETE WITH INSULATOR REMOVED


LOCATION OF WIRES ON CROSSARM
STRAIGHT LINE

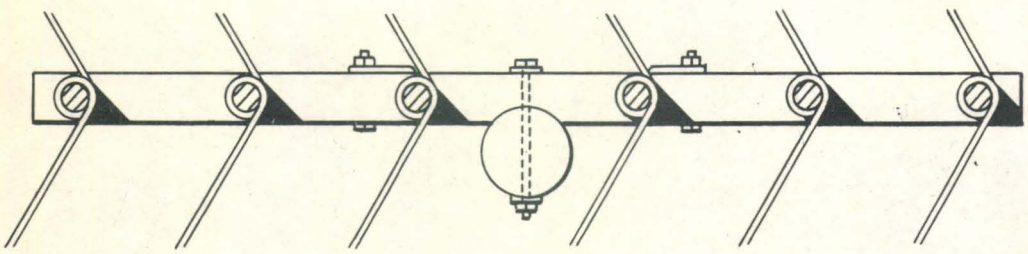

CURVE OR CORNER

FIGURE 22

WIRING STANDARDS

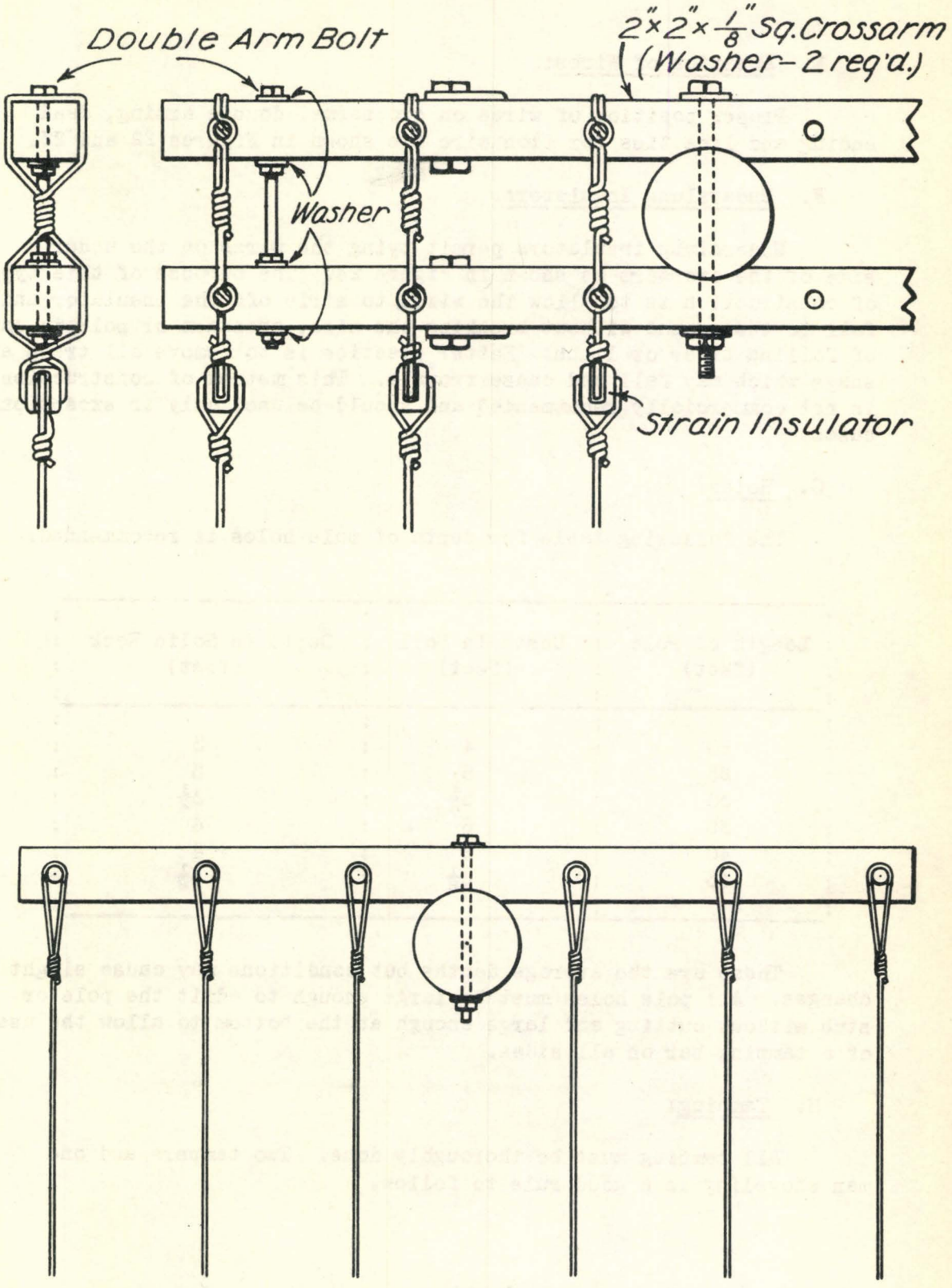


FIGURE 23

TWO METHODS OF DEAD ENDING

E. Position of Wires:

Proper position of wires on crossarms, double arming, dead ending and line ties for iron wire are shown in Figures 22 and 23.

F. Underslung Insulators:

Underslung insulators permit tying the wires on the under side of the crossarm as shown in Figure 24. The purpose of this type of construction is to allow the wires to strip off the insulator and fall to the ground without breaking the wire, crossarm or pole in case of falling trees or limbs. Better practice is to remove all trees and snags which may fall and cause trouble. This method of construction is not commercially recommended and should be used only in exceptional cases.

G. Holes:

The following table for depth of pole holes is recommended:

Length of Pole (feet)	Depth in Soil (feet)	Depth in Solid Rock (feet)
20	4	3
25	5	3
30	5½	3½
35	6	4
40	6	4
45	6½	4½

These are the average depths but conditions may cause slight changes. All pole holes must be large enough to admit the pole or stub without cutting and large enough at the bottom to allow the use of a tamping bar on all sides.

H. Tamping:

All tamping must be thoroughly done. Two tampers and one man shoveling is a good rule to follow.

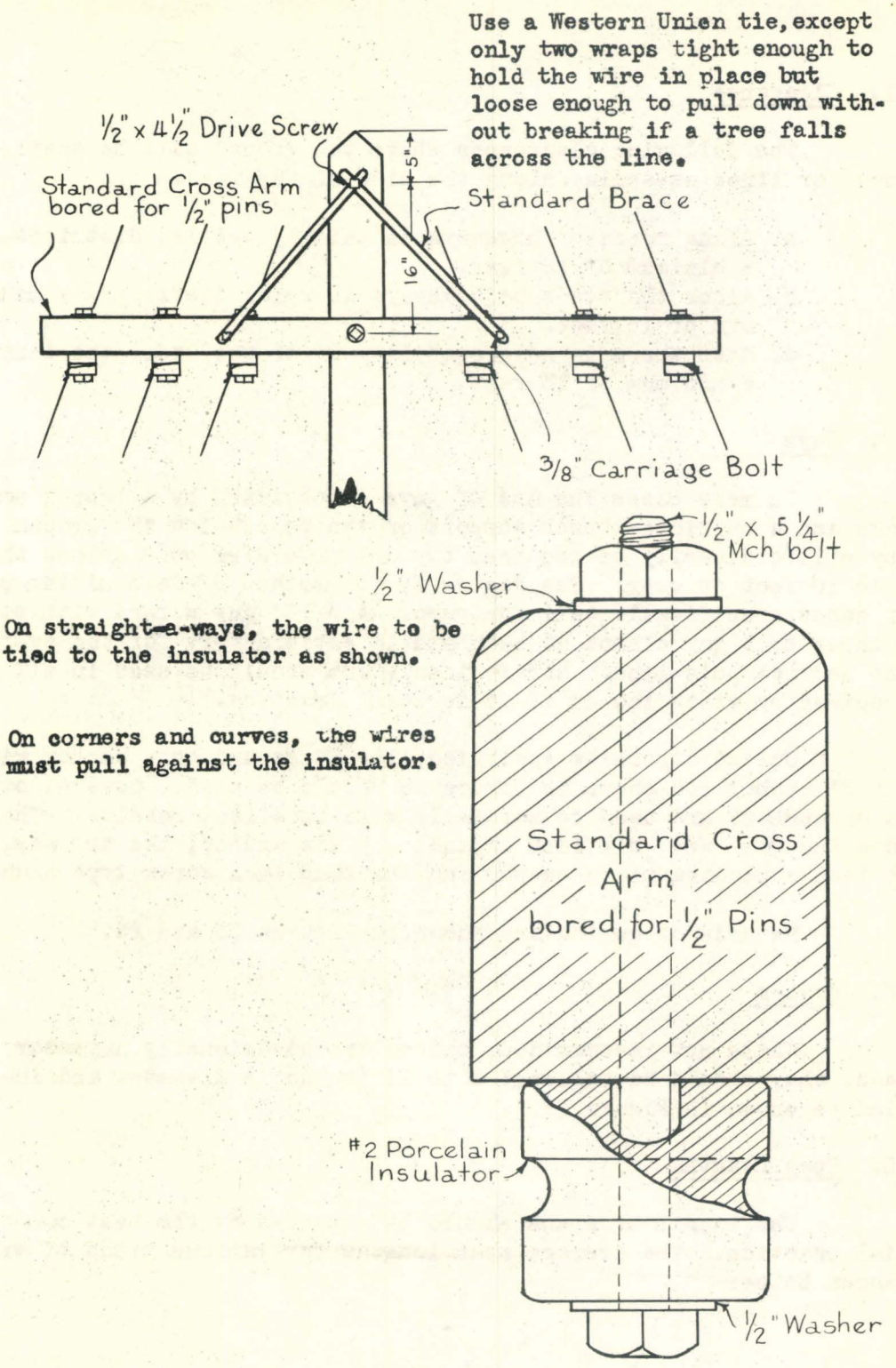


FIGURE 24

UNDERSLUNG INSULATOR CONSTRUCTION

I. Clearance

The following clearances above the ground will be satisfactory for lines extending along the side of the road.

a. Along roads or highways in thickly settled districts, a minimum of 18 feet.
b. Along the roads or highways in rural districts, a minimum of 15 feet.
c. When there is no probability of travel under the line a minimum of 13 feet.

J. Guys

In many cases the use of guys is obviated by a proper amount of rake and a sufficient rock support of the pole below the ground line. No guy will ordinarily be required for a 2 or 4 wire pole unless the pull is 10 feet or over. See Figure 27 for method of determining pull. Other cases specifically call for guys. A 5/16" guy strand with standard three bolt guy clamps at each end is satisfactory for the average Forest Service pole line. Strain insulators should be used in all guys if required by state law or if it is local practice.

Unless otherwise specified, the 8" ground cone anchor with 5/8" x 8' anchor rod shown in Figure 28 should be used. Several other types of anchors are used commercially with excellent results. These include the four way, six inch expanding plate anchor, the two way, eight inch expanding plate anchor and the four inch screw type anchor.

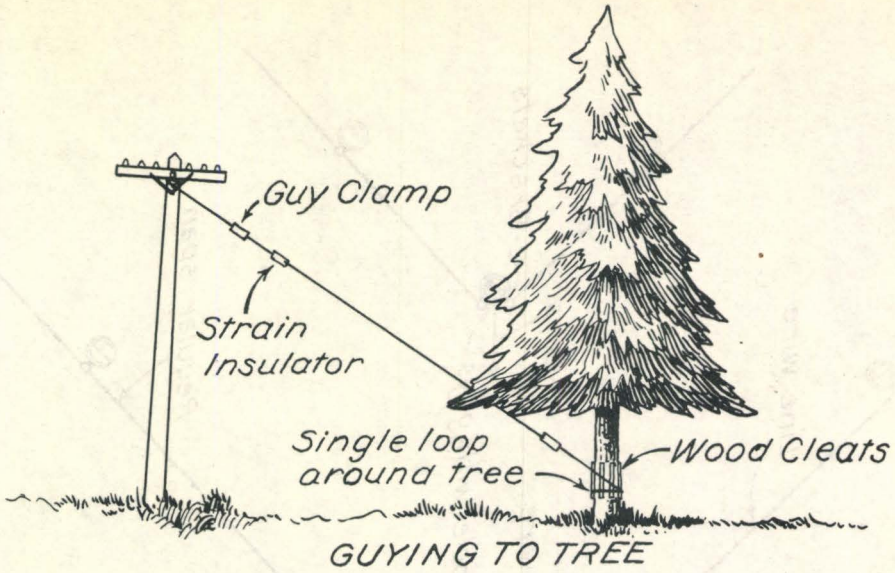
Methods of guying are shown in Figures 25 and 26.

K. Braces

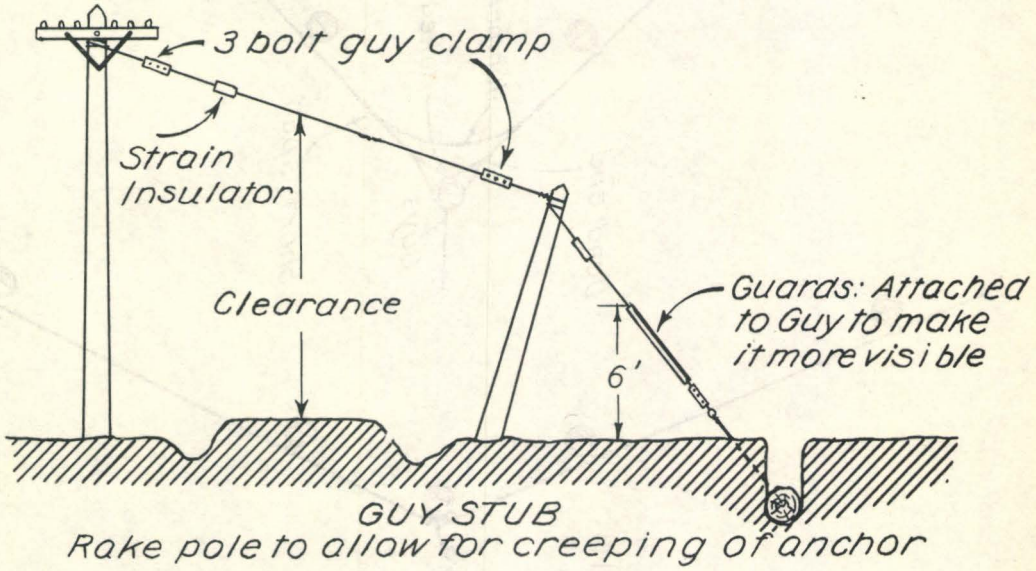
While not recommended, braces are occasionally necessary. If used, they should be at least 8 to 10 inches in diameter and installed as shown in Figure 27.

L. Span Lengths

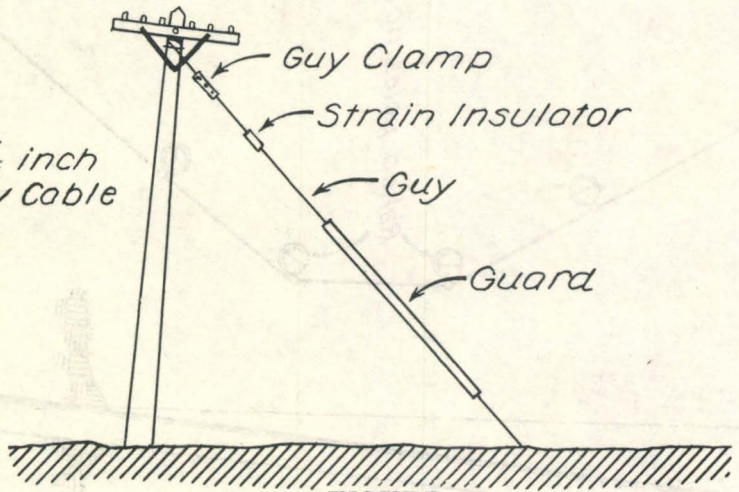
The length of spans should be governed by the best commercial practice. The average span lengths for various kinds of wire are shown below:



GUYING TO TREE



GUY STUB
Rake pole to allow for creeping of anchor



Note: Use $\frac{5}{16}$ inch 7 strand Guy Cable for all guys.

FIGURE 25

GUYING METHODS

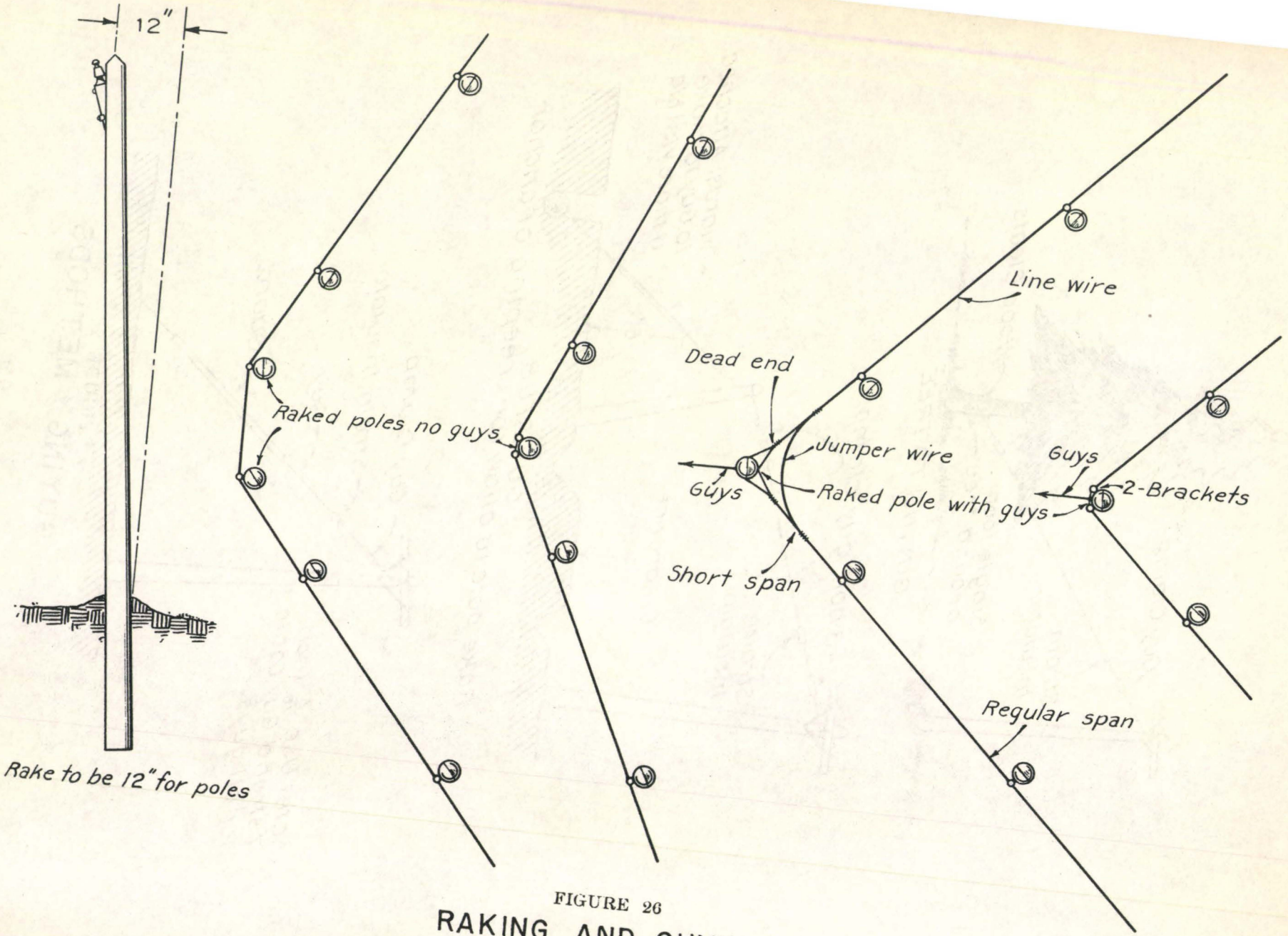
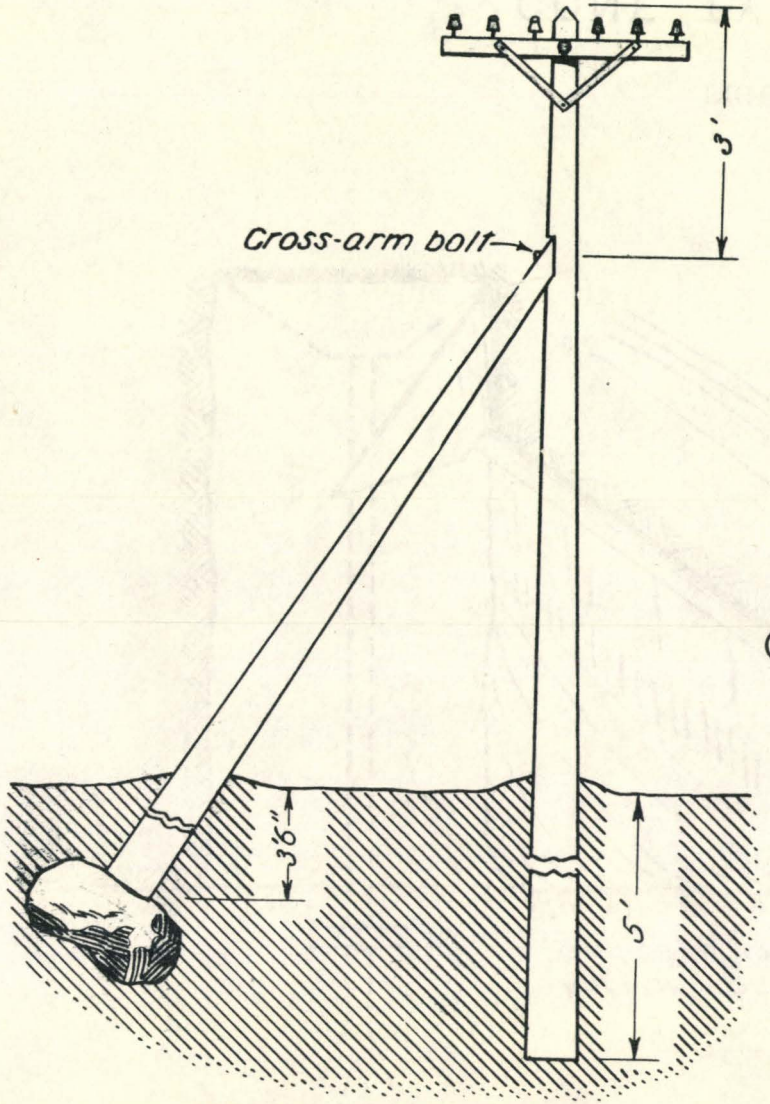
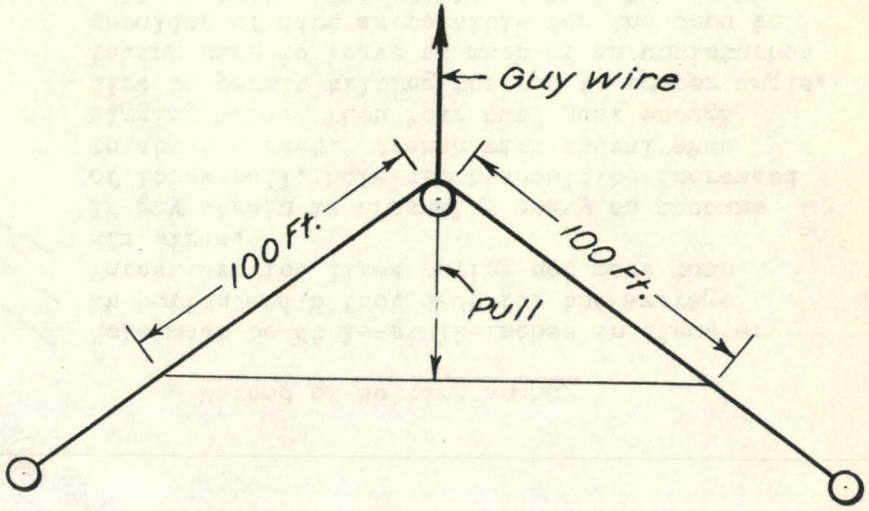


FIGURE 26

RAKING AND GUYING



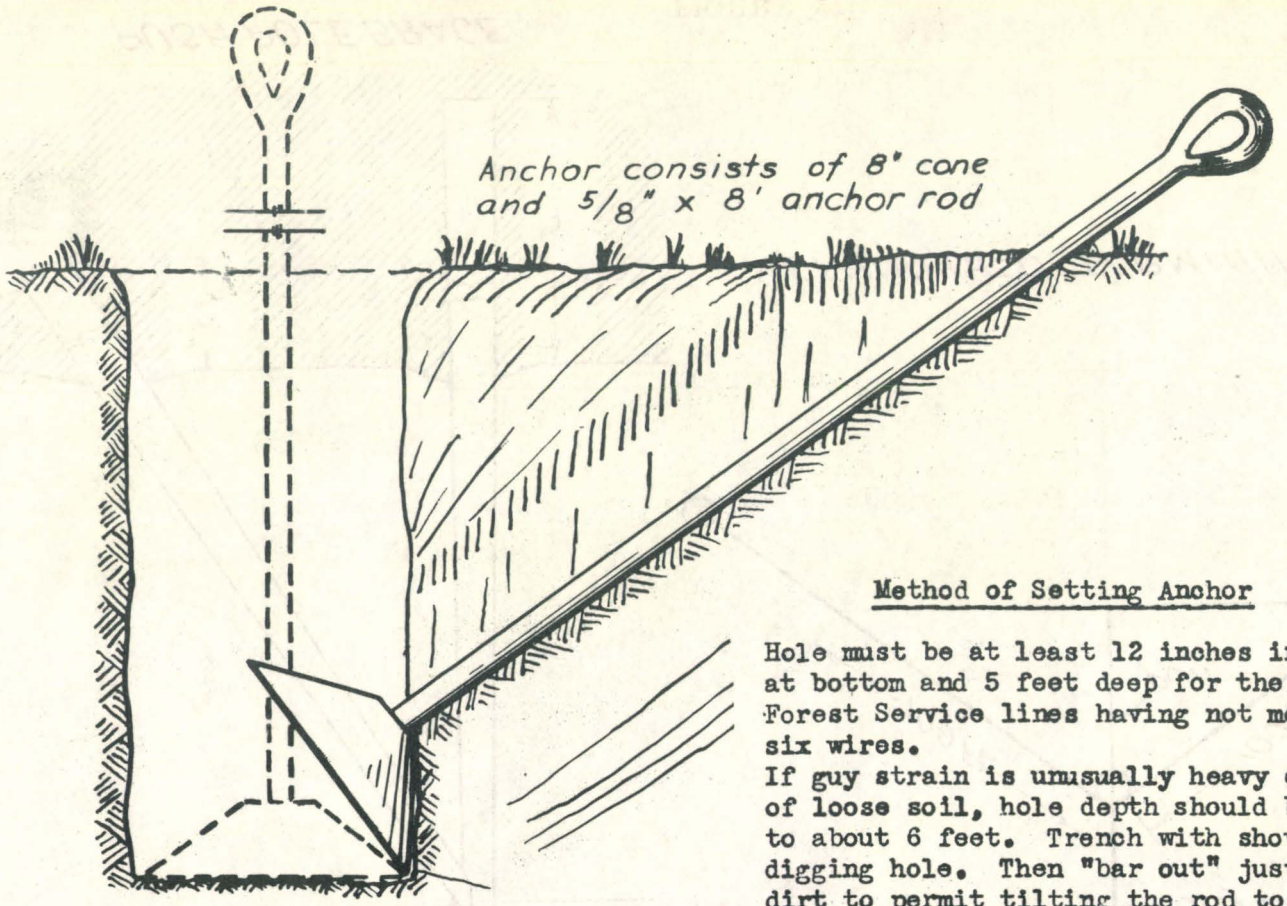
PUSH POLE BRACE



METHOD OF DETERMINING PULL

FIGURE 27

STANDARD PRACTICES



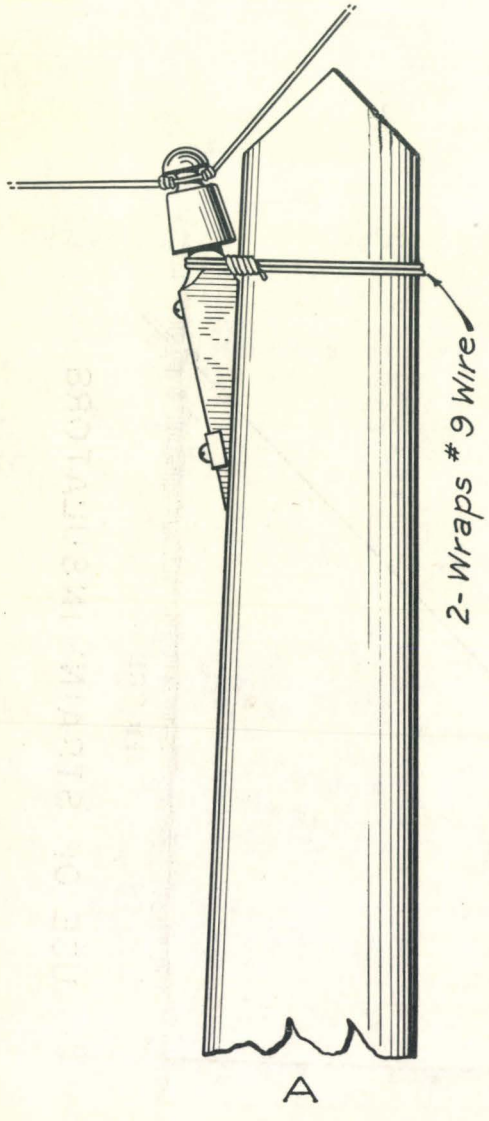
Method of Setting Anchor

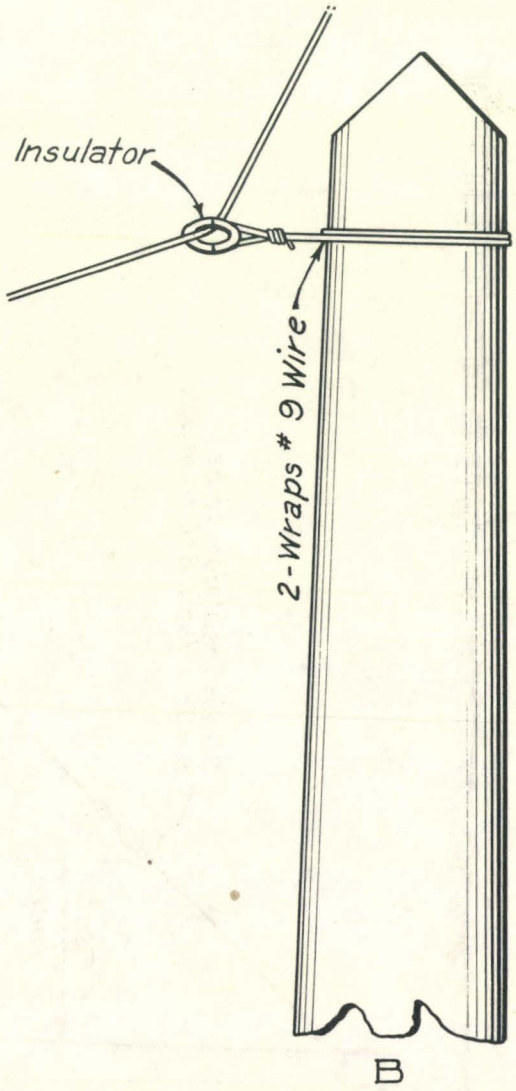
Hole must be at least 12 inches in diameter at bottom and 5 feet deep for the average Forest Service lines having not more than six wires.

If guy strain is unusually heavy on account of loose soil, hole depth should be increased to about 6 feet. Trench with shovel when digging hole. Then "bar out" just enough dirt to permit tilting the rod to proper angle, taking care to leave as much of an undisturbed shoulder of dirt as possible for the cone to pull against. Then fill and Tamp Thoroughly.

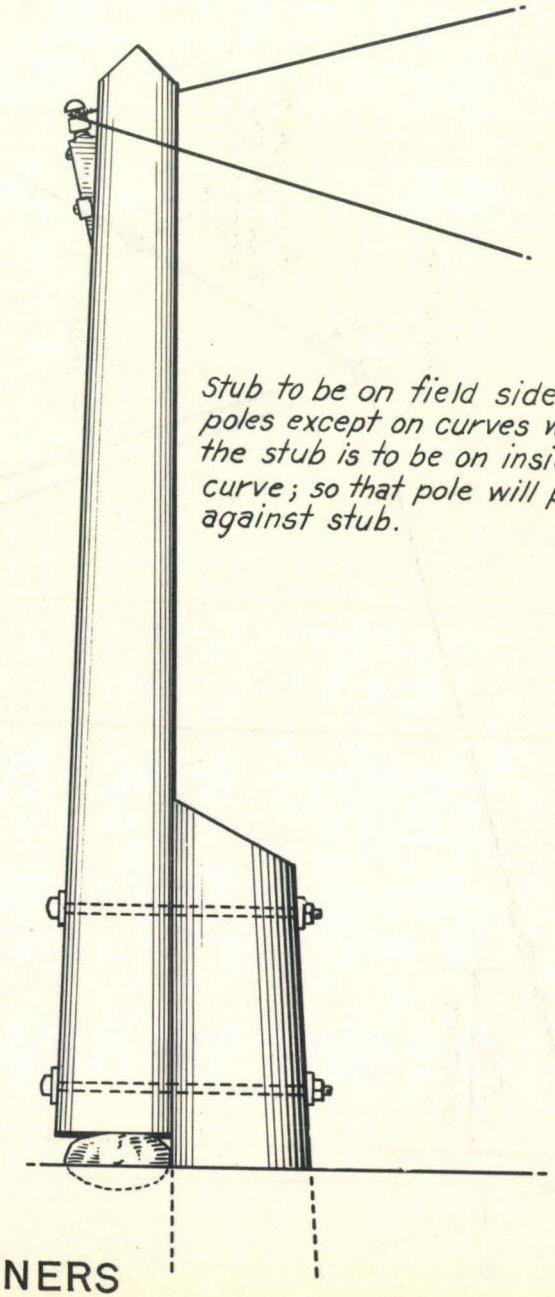
FIGURE 28

CONE TYPE ANCHOR





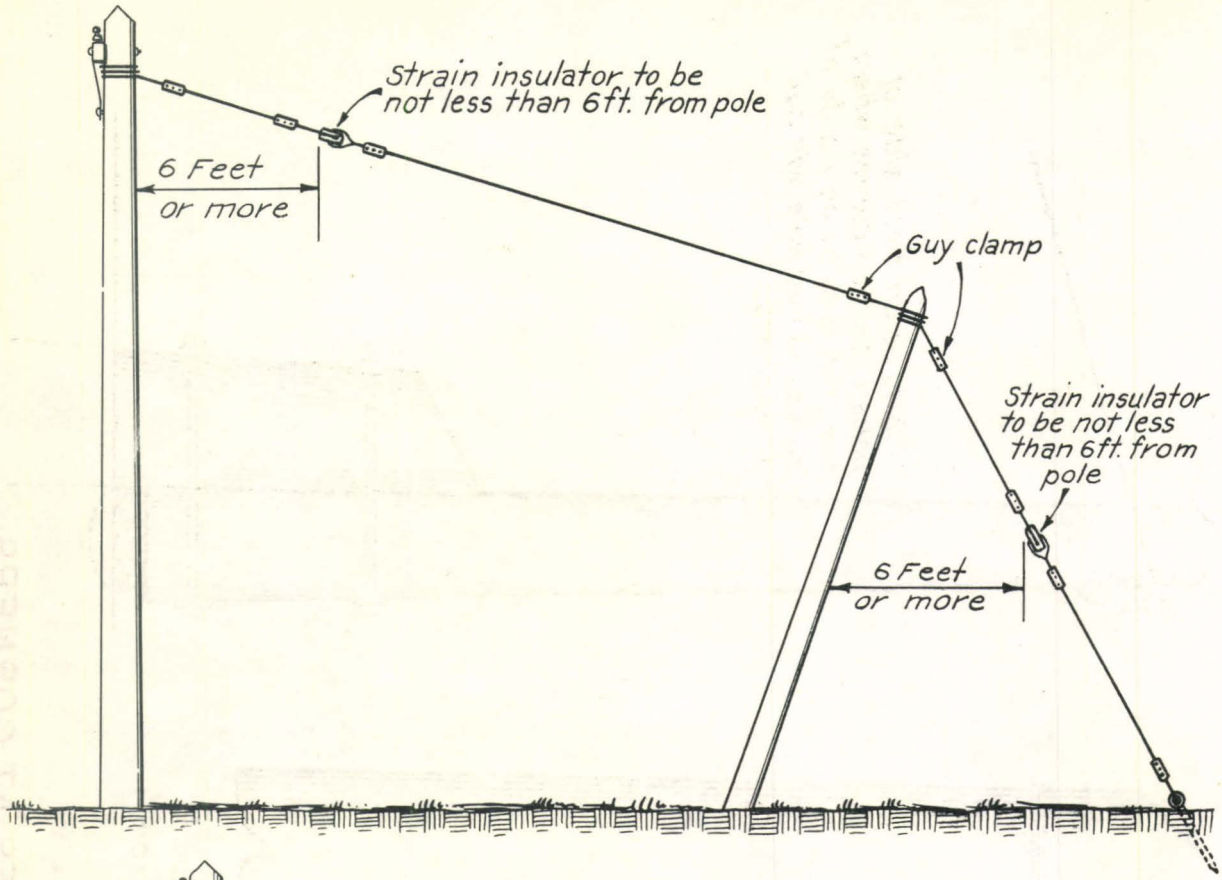
Method of attaching wire where pull away from the pole is unavoidable.
Method "B" is preferable



Stub to be on field side of poles except on curves where the stub is to be on inside of curve; so that pole will pull against stub.

FIGURE 29

ATTACHING WIRES AT CORNERS



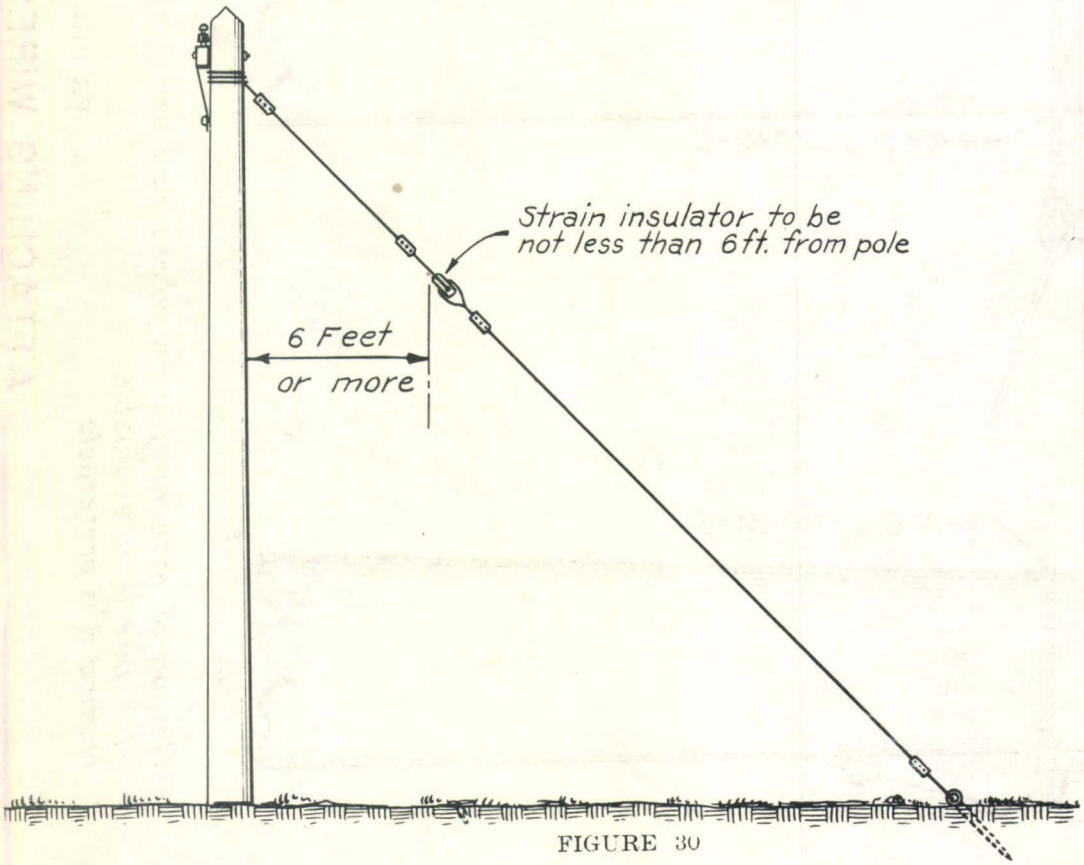


FIGURE 30

USE OF STRAIN INSULATORS

Kind of wire	Span length on straight stretches (feet)	Span length on curves or corners (feet)
No. 9 iron	140 to 160	125 to 150
No. 12 copper covered	160 to 175	135 to 150
No. 10 copper	125 to 140	100 to 125

In regions where there is no danger from sleet or ice, it will be permissible to increase the span length.

M. Sag

Curves for figuring a reasonable amount of sag to allow for various span lengths at a temperature of 60 degrees for No. 9 BWG galvanized E.B.B. iron wire, No. 10 or No. 12 A.W.G. copper covered or No. 10 A.W.G. hard drawn copper wire are shown in Figure 31. The following table gives the sag for No. 9 iron wire and No. 12 copper covered wire for various temperatures and various span lengths.

MEDIUM LOADING SAG
for
NUMBER 12 - 40% COPPER COVERED AND NUMBER 9 IRON WIRE

Length of span in feet	Temperatures Degrees Fahrenheit										
	100°	90°	80°	70°	60°	50°	40°	30°	20°	10°	0°
	Minimum Sag in Inches										
100	9	8	7	6	6	5	5	4	4	3	3
110	11	10	9	8	7	6	6	5	5	4	4
120	13	12	10	9	8	7	7	6	6	5	5
130	16	14	12	11	10	9	8	7	6	6	5
140	18	16	14	13	11	10	9	8	7	7	6
150	21	19	17	15	13	12	11	9	9	8	7
160	24	21	19	17	15	13	12	11	10	9	8
170	27	24	21	19	17	15	14	12	11	10	9
180	30	27	24	22	19	17	15	14	12	11	10
190	34	30	27	24	21	19	17	15	14	13	12
200	38	33	30	27	23	21	19	17	15	14	13
210	41	37	33	30	26	23	21	19	17	16	14
220	46	40	36	32	28	25	23	20	19	17	16
230	50	44	39	35	31	28	25	22	21	19	17
240	54	48	43	39	34	30	27	24	22	21	19
250	59	52	46	42	37	33	30	26	24	22	20
275	71	63	56	51	44	40	36	32	30	27	24
300	85	75	67	60	53	47	43	38	35	32	29
350	106	97	89	82	75	68	61	55	50	45	40
400	132	124	117	110	103	88	77	67	63	50	47
450	164	157	150	144	138	120	102	87	78	68	58
500	203	196	190	185	180	160	132	110	93	80	72

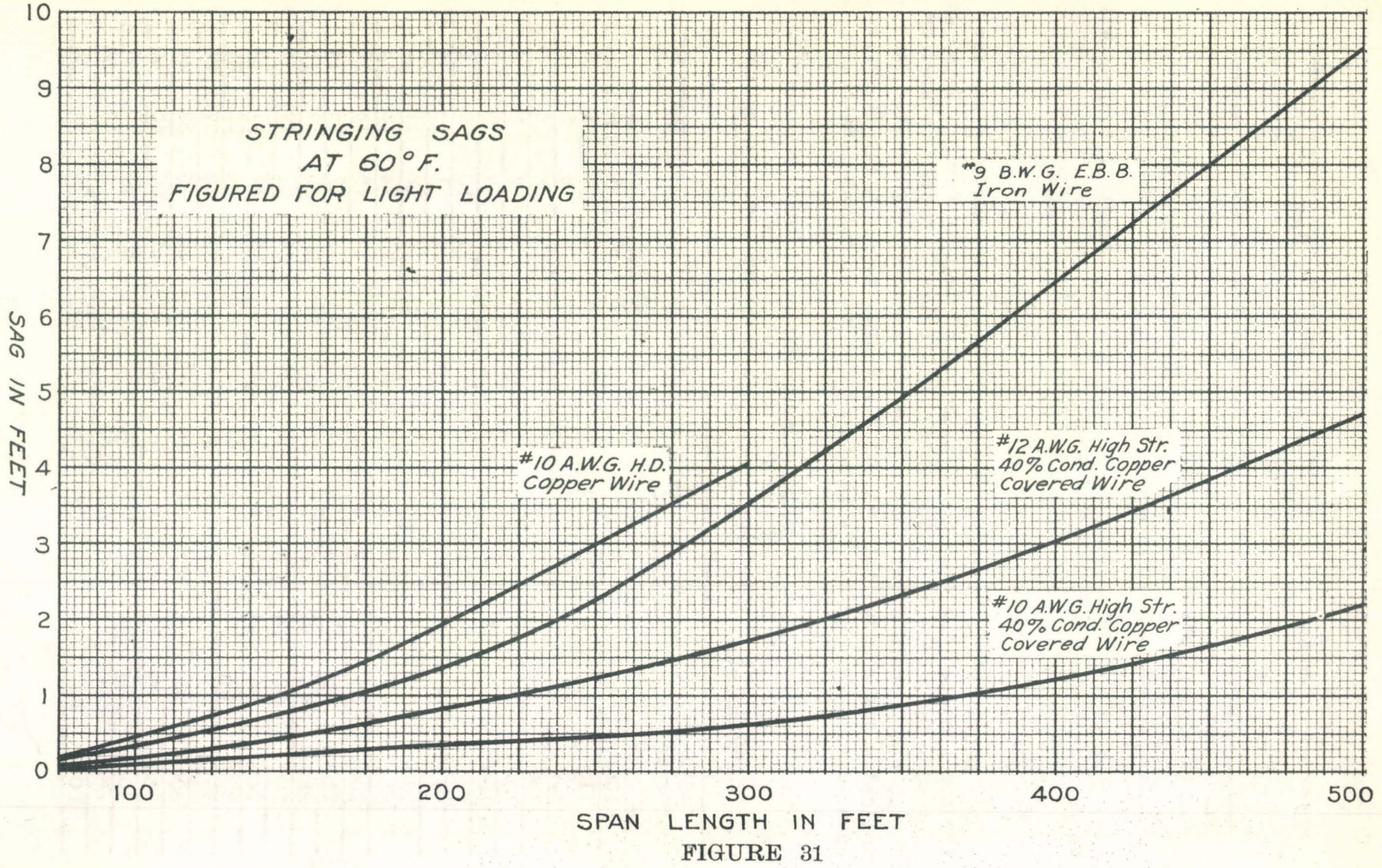


FIGURE 31

CURVES FOR CALCULATING SAGS

N. Crossings

1. Highways: Highway crossings should ordinarily be made overhead, if consistent with the State Highway Commission's policy, with short crossing spans made according to the best commercial practice. If it is a bracket line, two brackets should be used on the pole on each side of the road as shown in figure 32. With the approval of the Forest Supervisor, underground crossings may be made as shown in Figure 33 when it is impossible to secure a satisfactory clearance with an overhead crossing or when required by the State Highway Commission.

2. Railroad: A crossing with a railroad right of way must be made as required by the railroad company and in compliance with the State laws. They should ordinarily be made underground as shown in Figure 34. In no event should a buy or pole be set closer than 25 feet to the center of the track.

3. Electric Power Lines: If the power line is properly constructed and carries not to exceed 7500 volts, the crossing may be aerial with the telephone line at least 6 feet below the wires. Where the power line voltage is from 7500 to 25,000 volts, an underground crossing is preferable, made according to Figure 34. If an underground crossing is not practicable, an aerial crossing may be made with the telephone line at least 9 feet below the power line. Where the power line voltage is in excess of 25,000 volts, the crossing must be made underground in all cases unless otherwise specified by the Regional Forester.

4. Other Telephone Lines: Crossings with other telephone lines should generally be aerial, with a short crossing span and a clearance of 2 or 3 feet between lines. Whether such crossings should be made with the telephone wire over or under the wires of the other lines will be determined by the danger of the other wires falling upon the telephone line, or by other local conditions.

O. Interference

Interference in the operation of grounded circuit telephone lines may be caused by the proximity of:

1. Another grounded circuit telephone line, or a metallic circuit telephone line not properly transposed.
2. An electric power line.
3. A telegraph line.

In order to overcome such interference, it is necessary to make the telephone line metallic, with transpositions, as far as it parallels the other line. The above lines may cause inductive interference on a metallic circuit between wires. An unbalance in a metallic circuit will result if the wires are not of equal resistance or if there is a

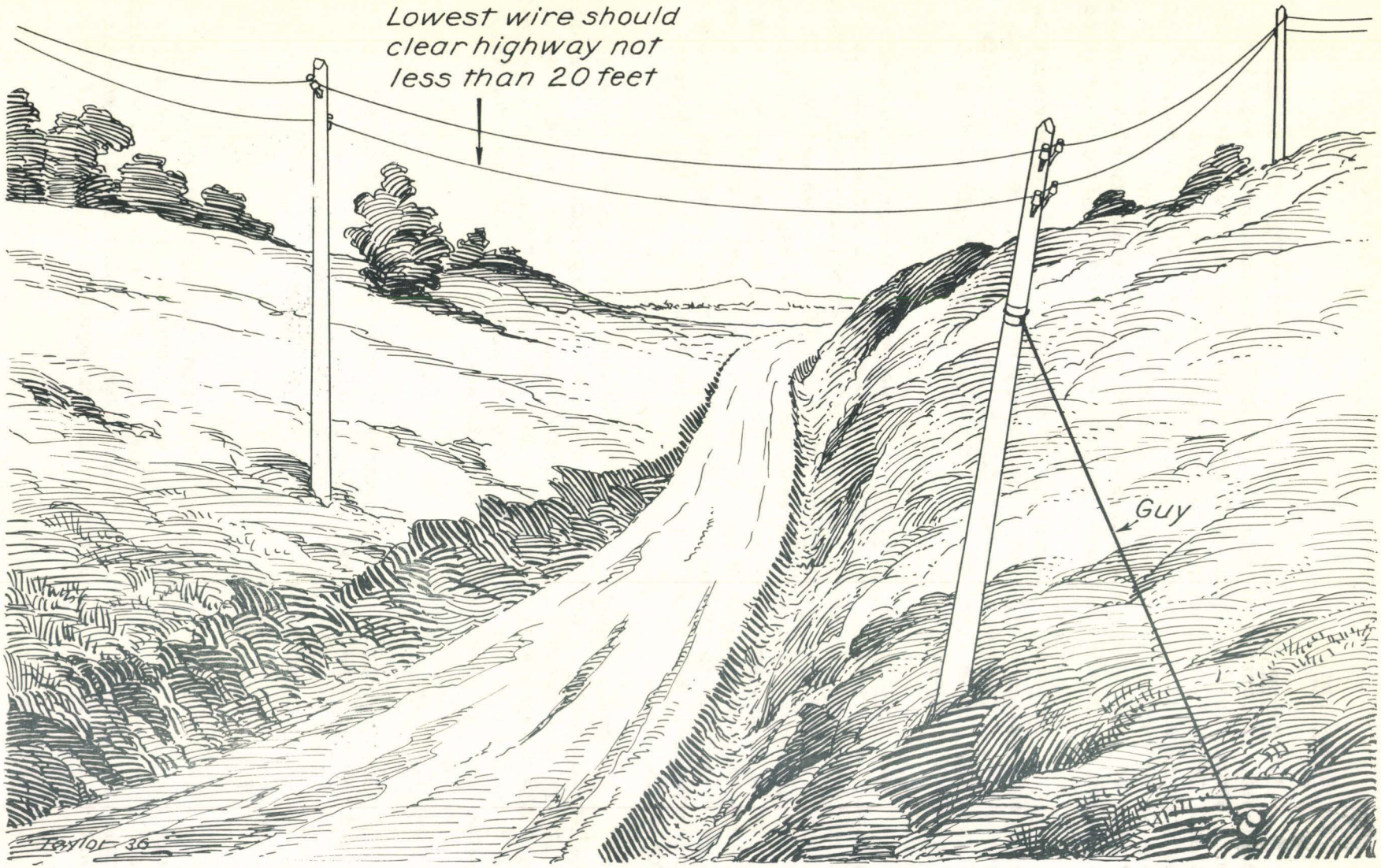


FIGURE 32

OVERHEAD HIGHWAY CROSSING

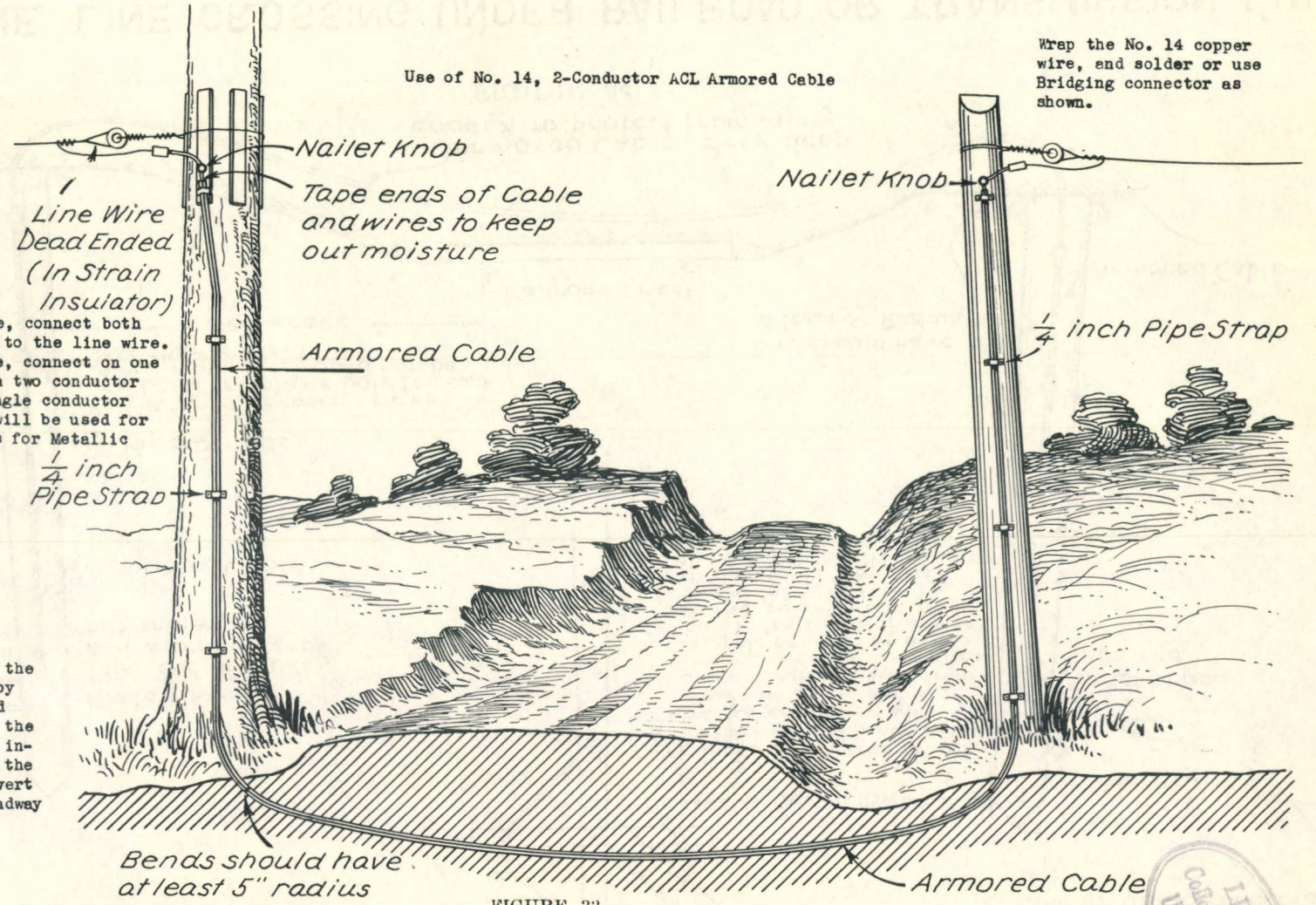


FIGURE 33

TELEPHONE LINE CROSSING UNDER HIGHWAY

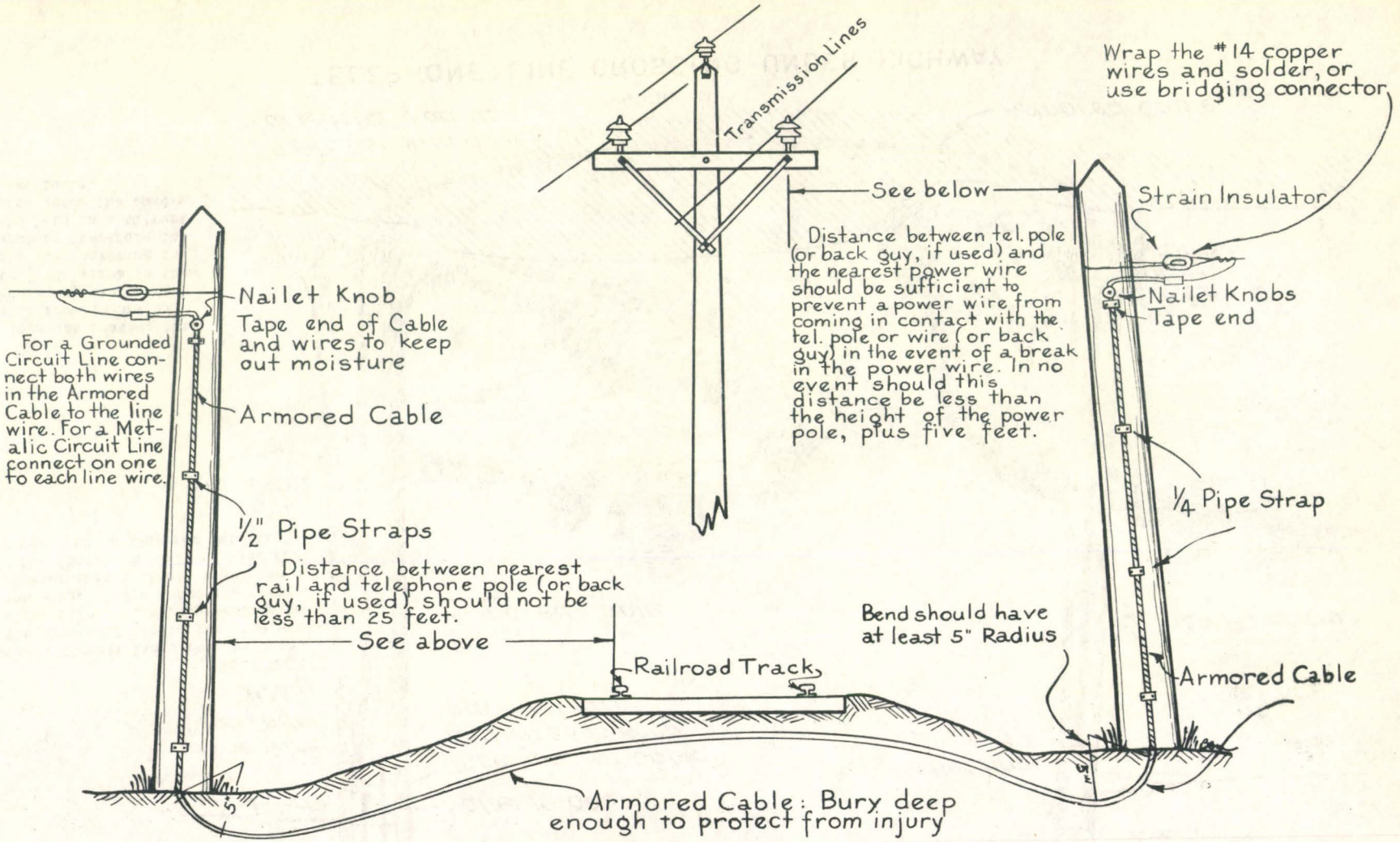


FIGURE 34

TELEPHONE LINE CROSSING UNDER RAILROAD OR TRANSMISSION LINE

high resistance leak from one side of the line to the ground.

Two or more Forest Service grounded circuit telephone lines may be on the same pole for 4 or 5 miles, provided the minimum distance between wires does not exceed about 2 feet. There will be little or no trouble caused by rings or howler signals, but there will be cross talk between the lines. The extent of this interference will be determined by the traffic (amount of talking) on the lines. If it can be avoided, a Forest Service grounded circuit line should not be strung on the same poles with grounded circuit lines owned by others.

It is not always possible to determine in advance the extent of the interference on a grounded circuit telephone line caused by an electric power line or a telegraph line, but it will probably be serious if either the power or the telegraph line is within 500 feet of the telephone line and extends parallel to it for more than a mile or two.

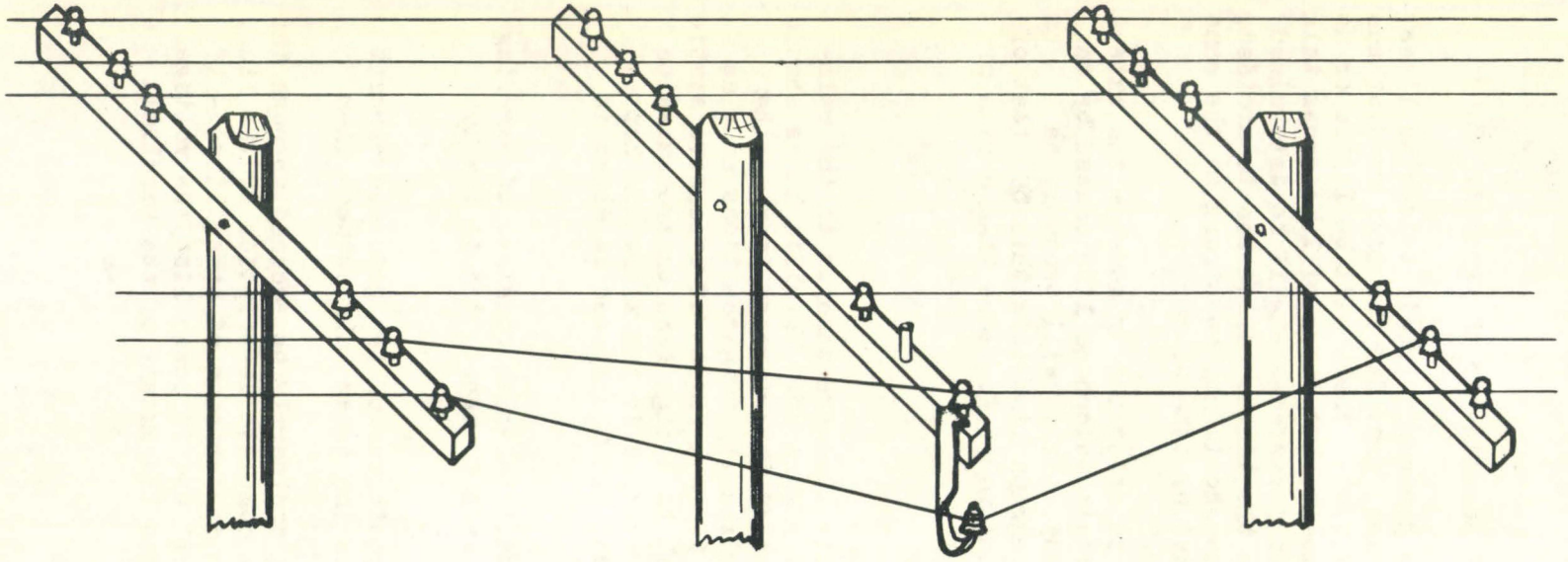
P. Transpositions

Transpositions in a metallic line are changes in the relative positions of the two wires. See Figure 35. Metallic lines should be transposed in order that the amount of interference from another line may be reduced in magnitude. Ordinarily transpositions made as shown are satisfactory. However, if it is a region of excessive static or if there is a fairly close parallel to a high tension transmission line, there will be a better balance secured if the wires are kept at about the same distance from the ground and transposed as shown in Figure 21.

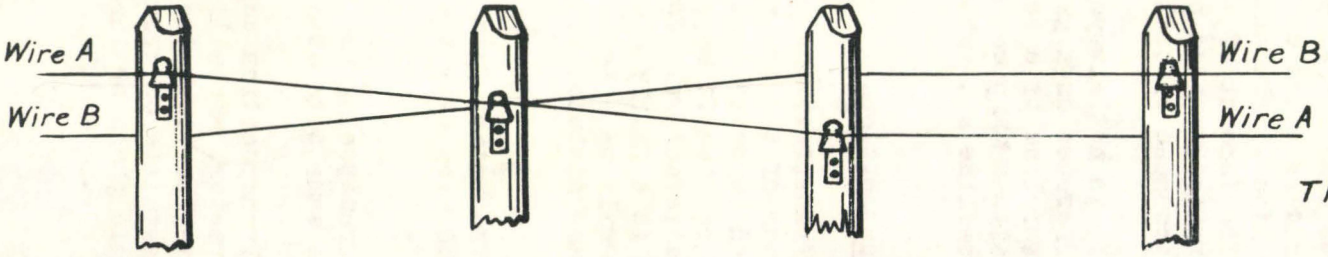
The rotary form of transposition which consists of carrying the left-hand wire over the other at each transposition is the most satisfactory.

Transposing the relative positions of two grounded circuit lines on the same pole does not reduce the cross talk between them.

Transposition schemes will ordinarily be secured through the Regional Forester, who will require a complete description of the line, including its location, proximity and description of other lines - if telephone, metallic or grounded circuit and if power line the voltage, whether single phase or three phase and the extent of the parallel.



TRANSPOSITION FOR CROSS ARM LINE



TRANSPOSITION FOR BRACKET LINE

TRANSPOSITION BRACKET

All rotations in all cases are made clockwise

FIGURE 35

TRANSPOSITION METHODS

Q. Phantom Circuits

A grounded phantom circuit line, Figure 36, can be operated on a physical metallic circuit line and simultaneous use of both circuits will be possible without an appreciable amount of cross talk between them, provided the metallic circuit is well balanced; that is:

a. Both wires are of the same size and resistance and are free from grounds.
b. The two wires are properly transposed (see paragraph on transpositions) and, except at transpositions, to have a uniform separation and spaced not to exceed 15 inches apart.
c. In bracket construction the wires should be spaced equal distance from the ground as shown on Figure 21.
d. There are no paralleling lines which would cause interference in an ordinary grounded circuit line.

A metallic phantom circuit, Figure 37, can be operated on two physical metallic circuits, and simultaneous use of all three circuits will be possible without cross talk between them. There will not be inductive interference caused by other telephone, telegraph, electric power lines or static, provided:

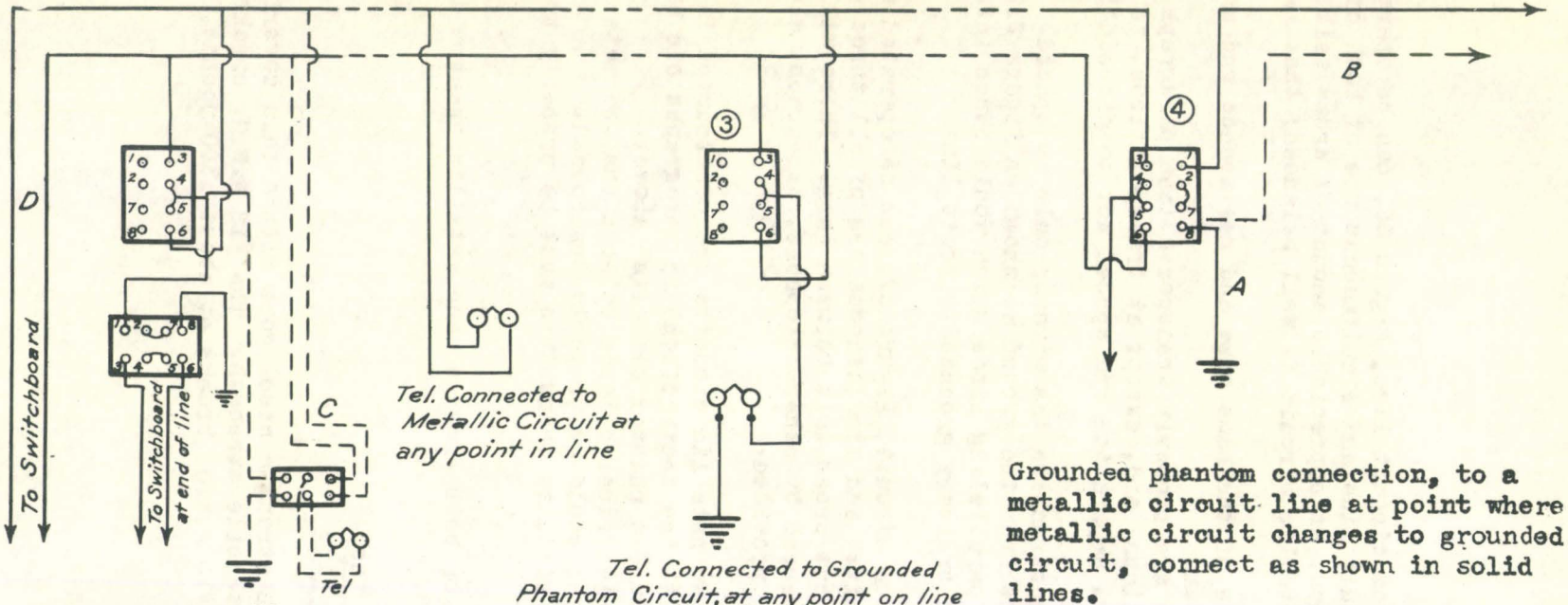
a. Each of the two metallic circuits are constructed in accordance with the instructions in paragraphs one and two under grounded phantom circuits above.
b. There is an electrical balance between the two metallic circuits, which could be properly transposed.
c. The metallic circuits themselves must be properly transposed.

A schematic diagram of both grounded and metallic phantom circuits is shown in Figure 38.

33. Instructions Covering the Use of Copper Covered Wire

This wire has a high strength steel core with a thin covering of copper. It has a high tensile strength. The #12 A.W.G. breaks at about 785 pounds, and the #10 A.W.G. breaks at about 1300 pounds.

For superimposing a grounded phantom circuit line on a metallic circuit line, using Kellogg No. 21 A repeat coil. If it is desired to use Graybar No.77A repeat coil, connect as shown on Figure 42.



At End of Line

If both the grounded phantom and metallic circuits are to be connected to a switchboard, the connection should be made as shown in sold lines, using both repeat coils.

If the circuits are to be connected to a telephone through a switch, instead of a switchboard, wire as shown in dotted lines "C" and omit lower repeat coil and wires connected to it, also wire "D".

Grounded phantom connection, to a metallic circuit line at point where metallic circuit changes to grounded circuit, connect as shown in solid lines.

If, instead of a change to a grounded circuit line, the metallic circuit line extends beyond this point and parallels either electric power line or grounded circuit telephone lines, connection should be made as shown above except that the ground wire "A" is omitted and the other wire of the metallic circuit "B" (shown as dotted line) is connected to the repeat coil instead of the ground wire.

FIGURE 36

REPEAT COIL CONNECTION

For superimposing a metallic phantom circuit line on two physical metallic circuit lines, using all Kellogg # 21A repeat coils. If it is desired to use Graybar #77A repeat coils, connect as shown on figure 42.

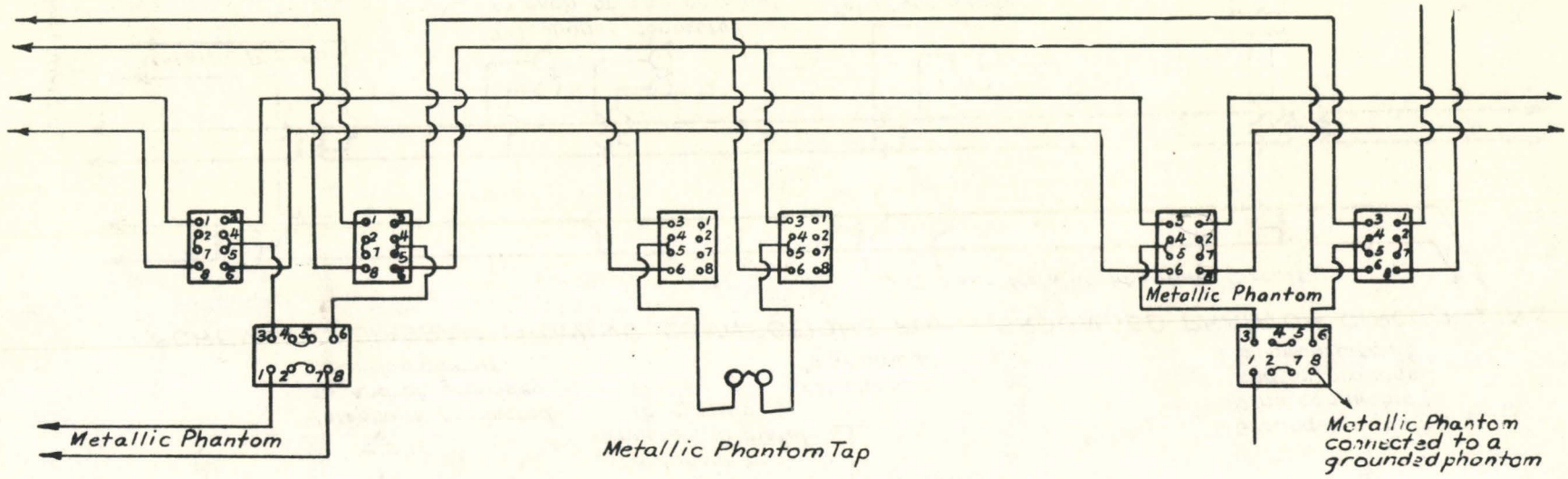
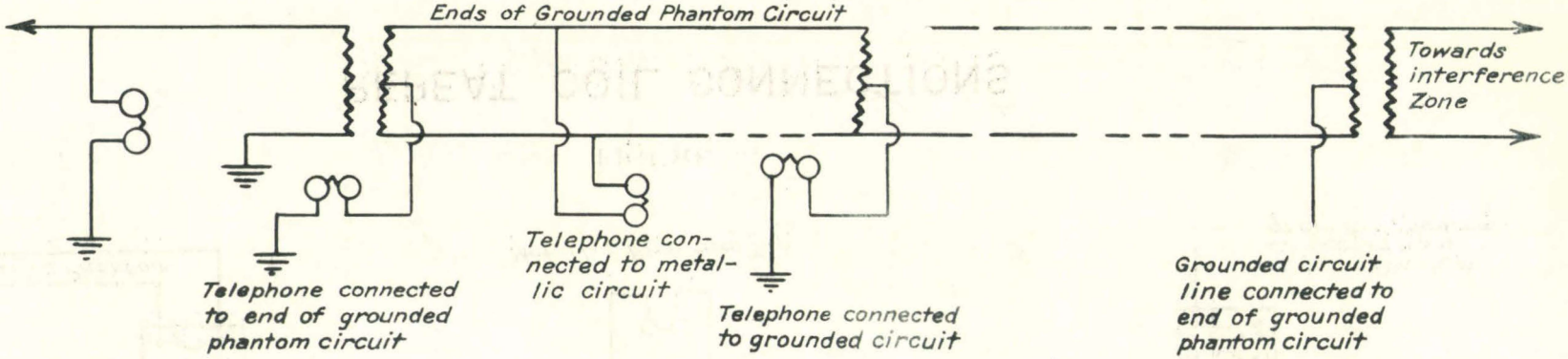
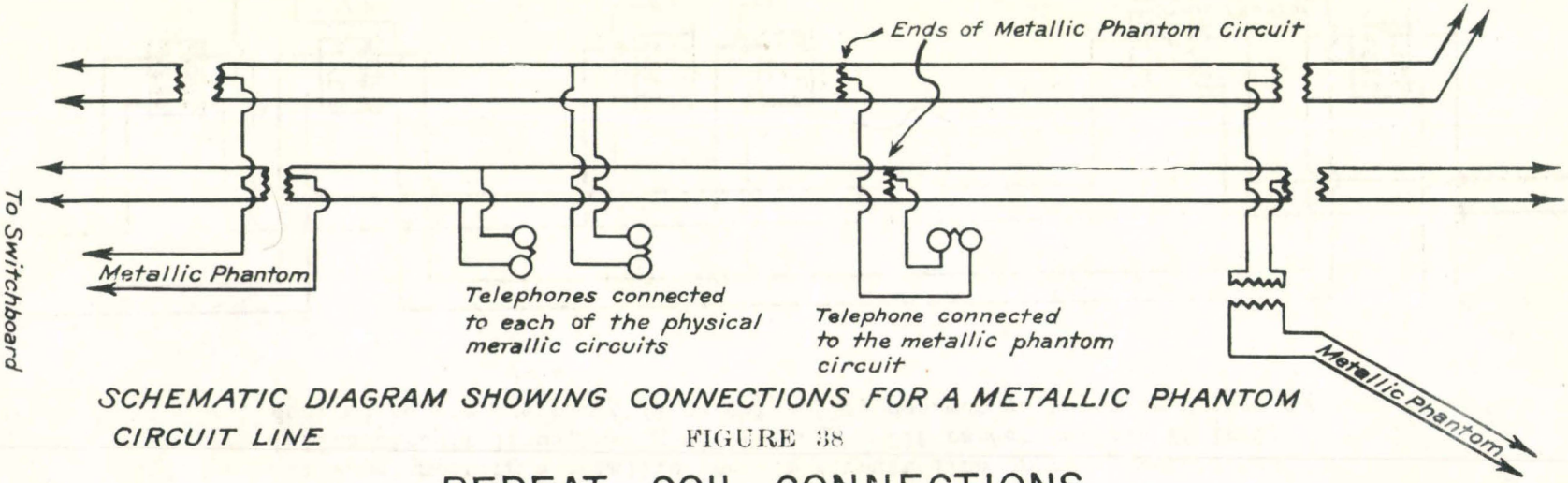


FIGURE 37

REPEAT COIL CONNECTIONS



SCHEMATIC DIAGRAM SHOWING CONNECTIONS FOR A GROUNDED PHANTOM CIRCUIT LINE



SCHEMATIC DIAGRAM SHOWING CONNECTIONS FOR A METALLIC PHANTOM CIRCUIT LINE

FIGURE 38

REPEAT COIL CONNECTIONS

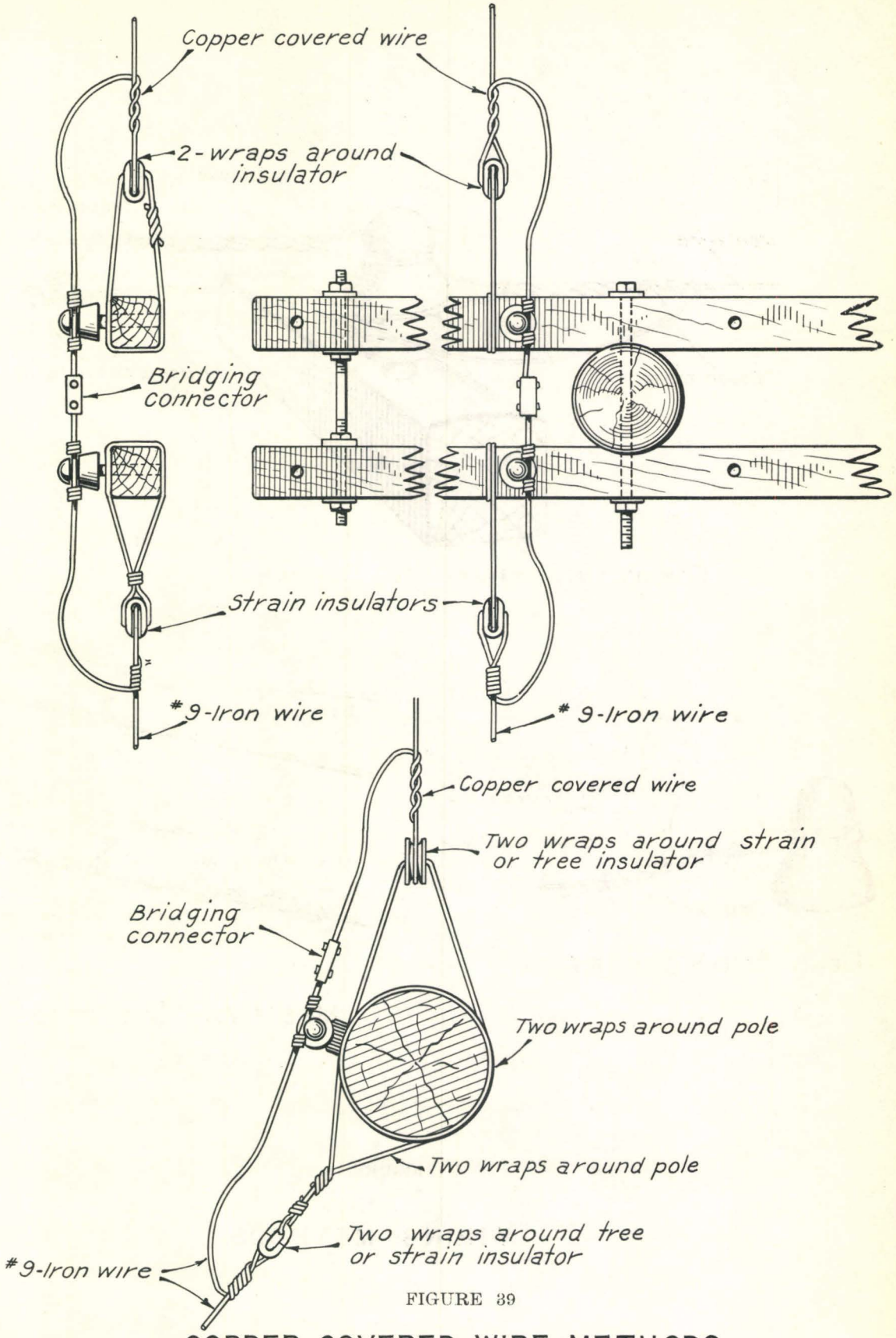
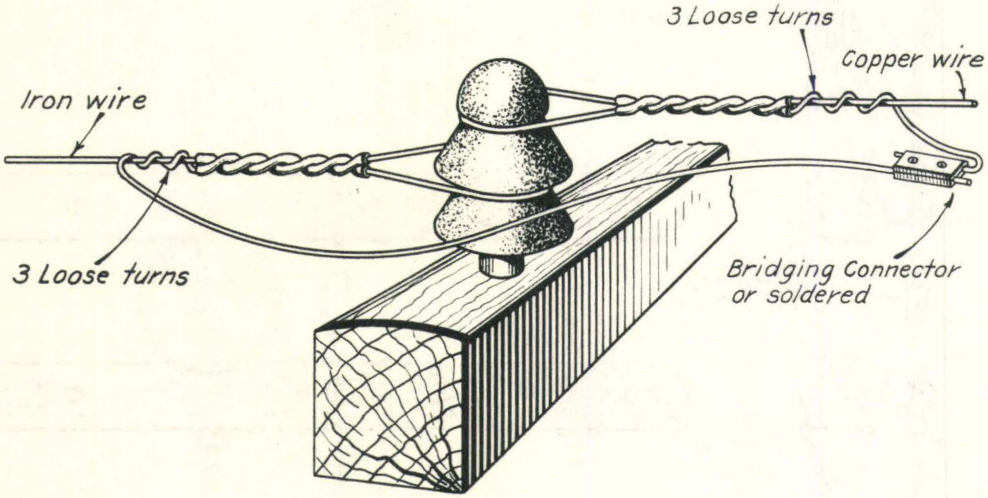
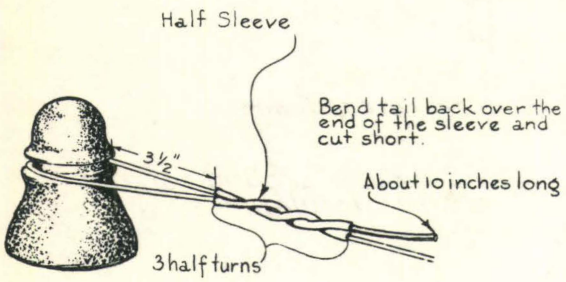


FIGURE 39

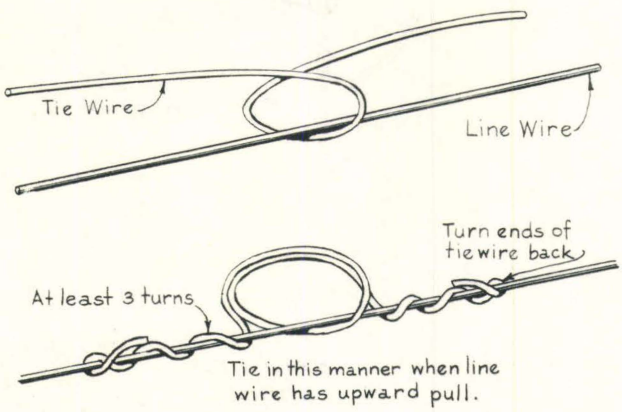
COPPER COVERED WIRE METHODS



CONNECTING IRON TO COPPER



DEAD ENDING WIRE



MODIFIED HORSESHOE TIE

FIGURE 40

WIRING METHODS

In handling the wire while in transit or in stringing, care must be taken to avoid injuring the copper covering. When stringing the wire, it should be paid out from the reel as it is carried along, if this is practicable. In the event it is necessary to have the reel set stationary, care must be taken in pulling out the wire to avoid dragging it over the rocky ground so as not to injure the copper covering. Avoid using pliers when making ties or stringing or pulling out the wire. Use only comealongs with smooth jaws when pulling slack.

Diagrams describing line ties, line connections, dead ending and connecting copper covered and iron wire together will be found on Figures 39 and 40.

34. Instructions Covering the Use of No. 10 hard drawn Copper Wire

While hard drawn copper wire has a high conductivity or low resistance, it has a comparatively low tensile strength. The #12 breaks at 337 pounds and the #10 at 528 pounds. Therefore, nothing smaller than No. 10 will be used. The wire will break easily if nicked or kinked and should be handled carefully. When stringing, the wire may be pulled out with the reel stationary if care if taken not to injure the wire when it is dragged over the ground. Avoid using pliers when making ties and stringing or pulling out the wire. Use only comealongs with smooth jaws when pulling slack.

Diagrams describing dead ending, ties and connections will be found in Figure 40.

SECTION VI - MISCELLANEOUS EQUIPMENT

35. Repeat Coils:

A repeat coil connected as shown in figure 41 should be used wherever it is desired to connect a grounded circuit and a metallic circuit line. If they are to be placed outside, and exposed to the weather, protection and test switches should be installed as shown in figure 42, and they may be installed on the pole as shown in figures 43 and 44.

36. Telephone Installation:

The equipment and material used, and the character of the work done at all regular telephone installations will conform to the following specifications and general instructions. Each region should standardize its type and make of telephone as far as practicable. Each telephone instrument shall be equipped with a generator having a ringing strength not less than that of a 5 bar magneto, a 2500 ohm ringer or bell coil, and a condenser in the receiver circuit. Many regions are using telephones having the equivalent of a 6 bar magneto. While a 2500 ohm ringer is the standard for all telephones and extension bells, there may be some instances where, in the interest of better fire control, it is good business to connect a Forest Service telephone line to one on which 1600 ohm ringers may be used. In this event, it is necessary that all ringer coils connected to a line, or lines tied together, have the same resistance, otherwise the coils with a low resistance will take more than their share of the ringing current. This is to be avoided if there is any other way out. One way might be to remove the bell coils in the 1600 ohm ringer telephones and substitute for them 2500 ohm ringer coils.

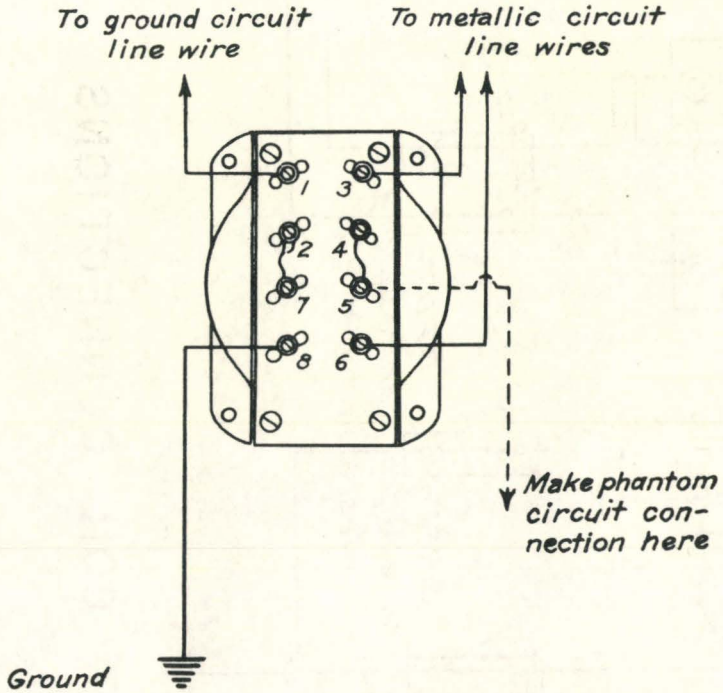
37. Locations of Equipment in a Building:

The telephone and switching apparatus should be located where it will be the most accessible for use and as close as possible to the lead-in wires.

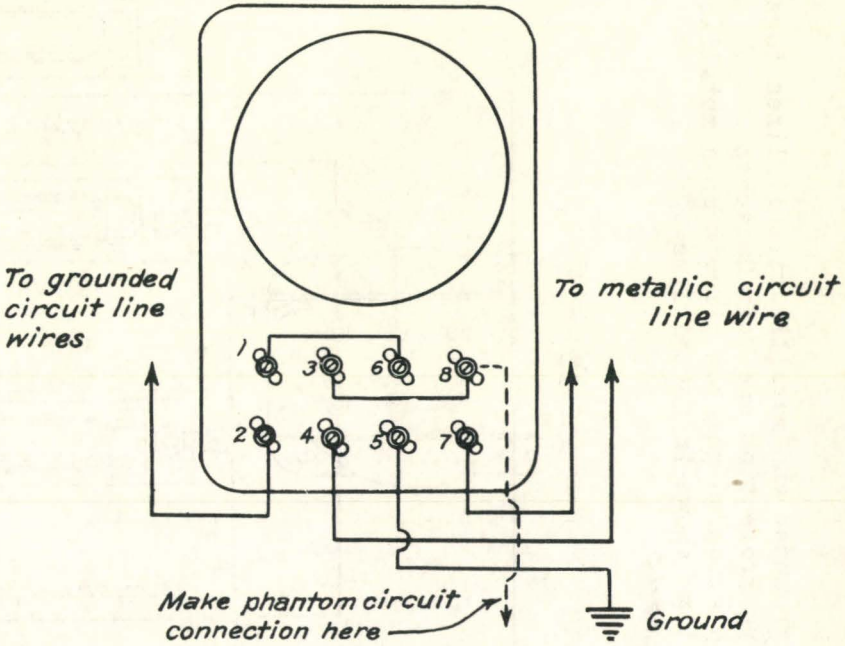
38. Drop Wires:

Drop or service wires should ordinarily be aerial. If aerial, they should be made as shown in figures 45, 46, and 47, taking

For changing from grounded to metallic circuit or reverse.



NO. 21 A REPEAT COIL



NO. 77A REPEAT COIL

If coils are mounted outside, (on pole or elsewhere) vacuum protectors are to be used, two on the metallic circuit side and one on the grounded circuit side.

Neither the coils nor the arresters are waterproof, therefore must be protected from the weather.

FIGURE 41

REPEAT COIL CONNECTIONS

For connecting grounded and metallic circuit lines together.
Showing Protection and Test Switches
Connection for a grounded phantom circuit on a metallic circuit line shown in dotted line.

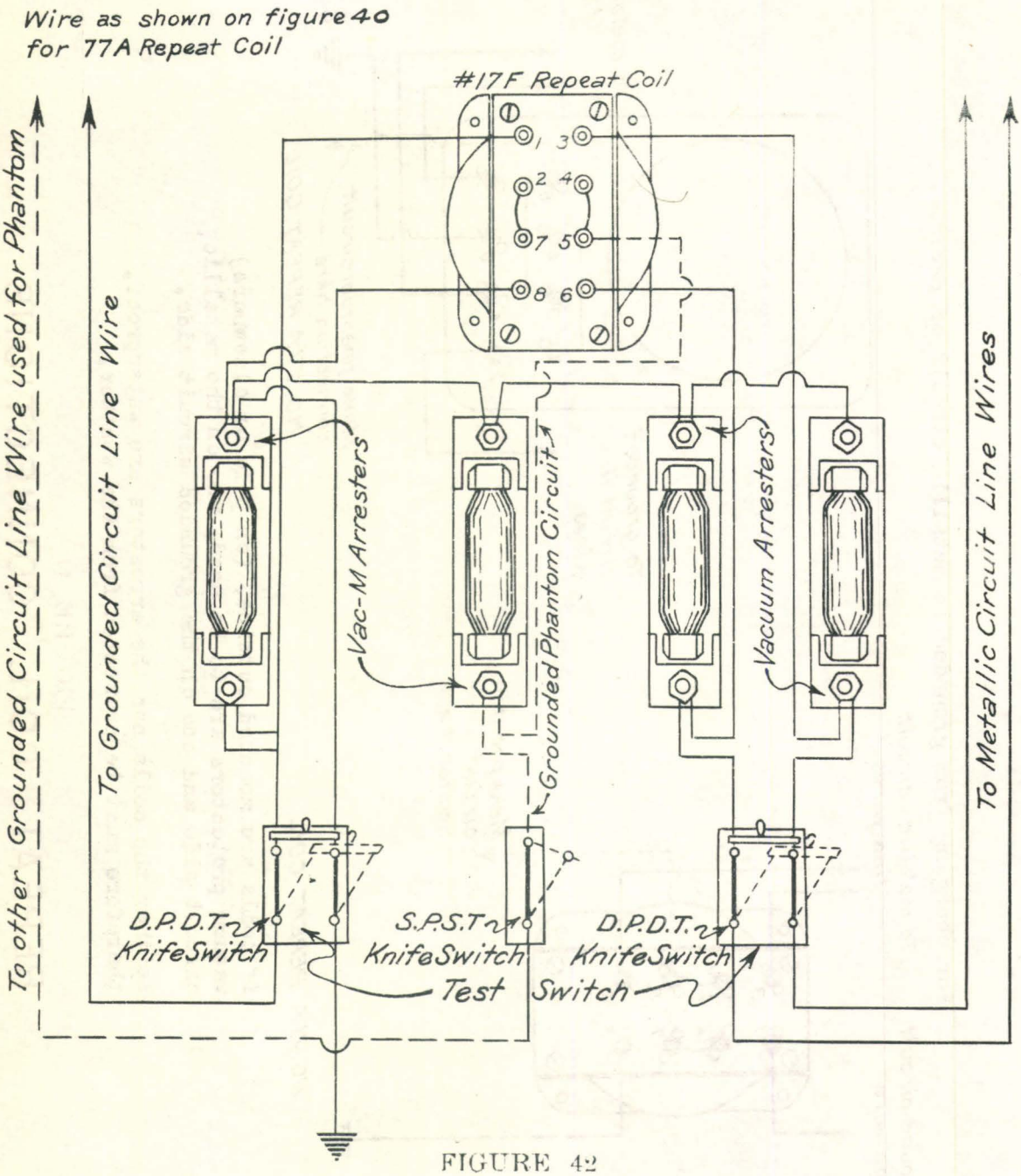


FIGURE 42

REPEAT COIL CONNECTIONS

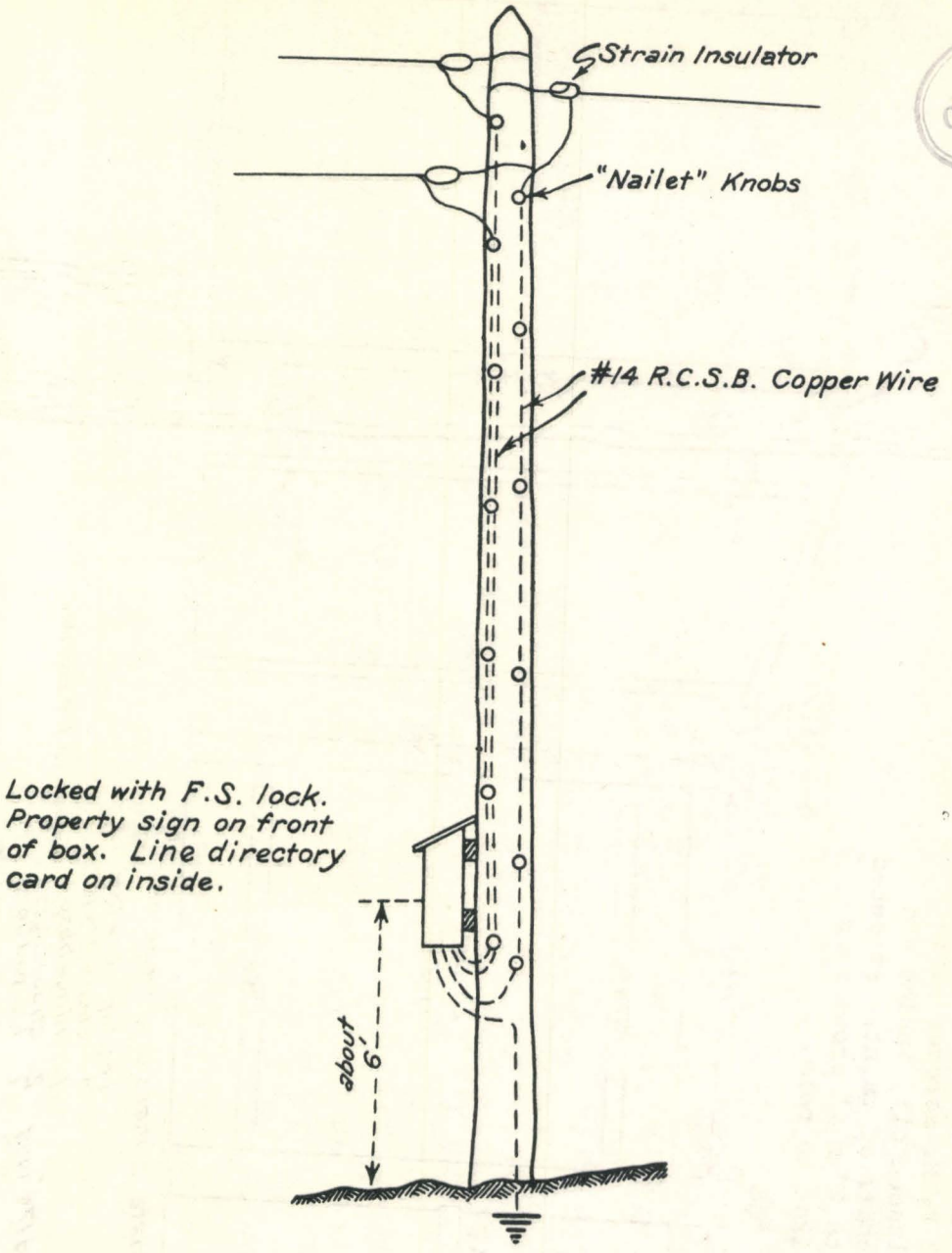
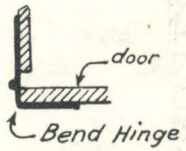


FIGURE 43

METHOD OF MOUNTING REPEAT COIL AND TEST BOX

Inside dimension of box should be 2 minimum of 10" wide x $4\frac{1}{2}$" deep x 16" high. Fastened together with $1\frac{1}{2}$" x #8 F. H. screws. Give 1 coat raw linseed oil, inside and out, then 2 coats of paint. Attached with screws to 2" x 4" cross arms $11\frac{1}{2}$" long spiked to pole.



Approximate dimensions Required

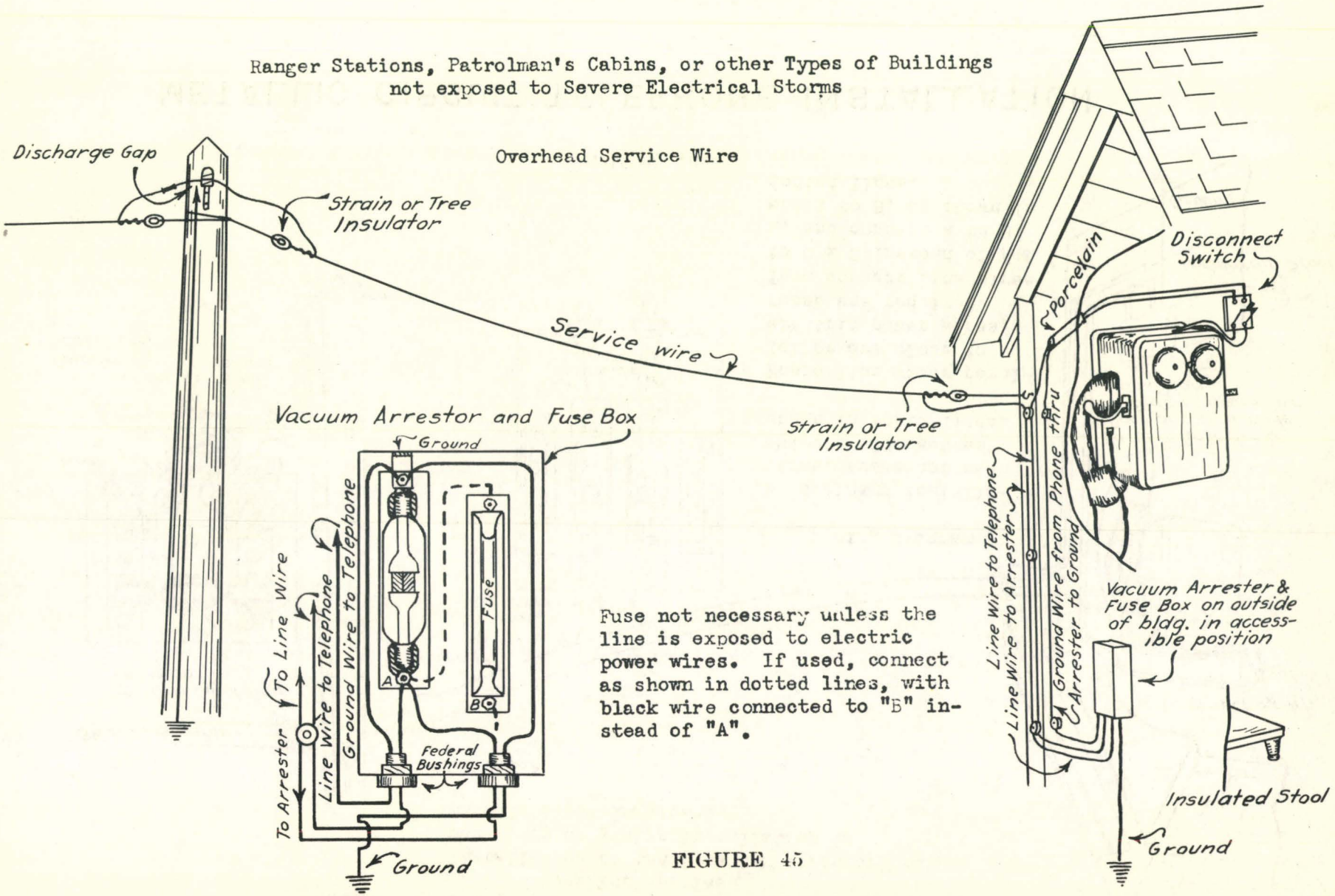
1 pc. back	11½" x 17½"	1 pc. top	8" x 13½"
1 " door	11½" x 14½"	2 " cleats	2" x 10"
1 " strip above door	11½ x 2"	1 hinge hasp	Galvanized if possible
2 " s sider	4½" wide by 16½" and 17½" long	2 strap hinges	
1 " bottom	4½" x 10"	1 F.S. pad lock	

3 doz. 1½" x #8 F.H. screws — 1½ doz. 1¼" x ¼ stove bolts

FIGURE 44

REPEAT COIL AND TEST BOX

Ranger Stations, Patrolman's Cabins, or other Types of Buildings
not exposed to Severe Electrical Storms

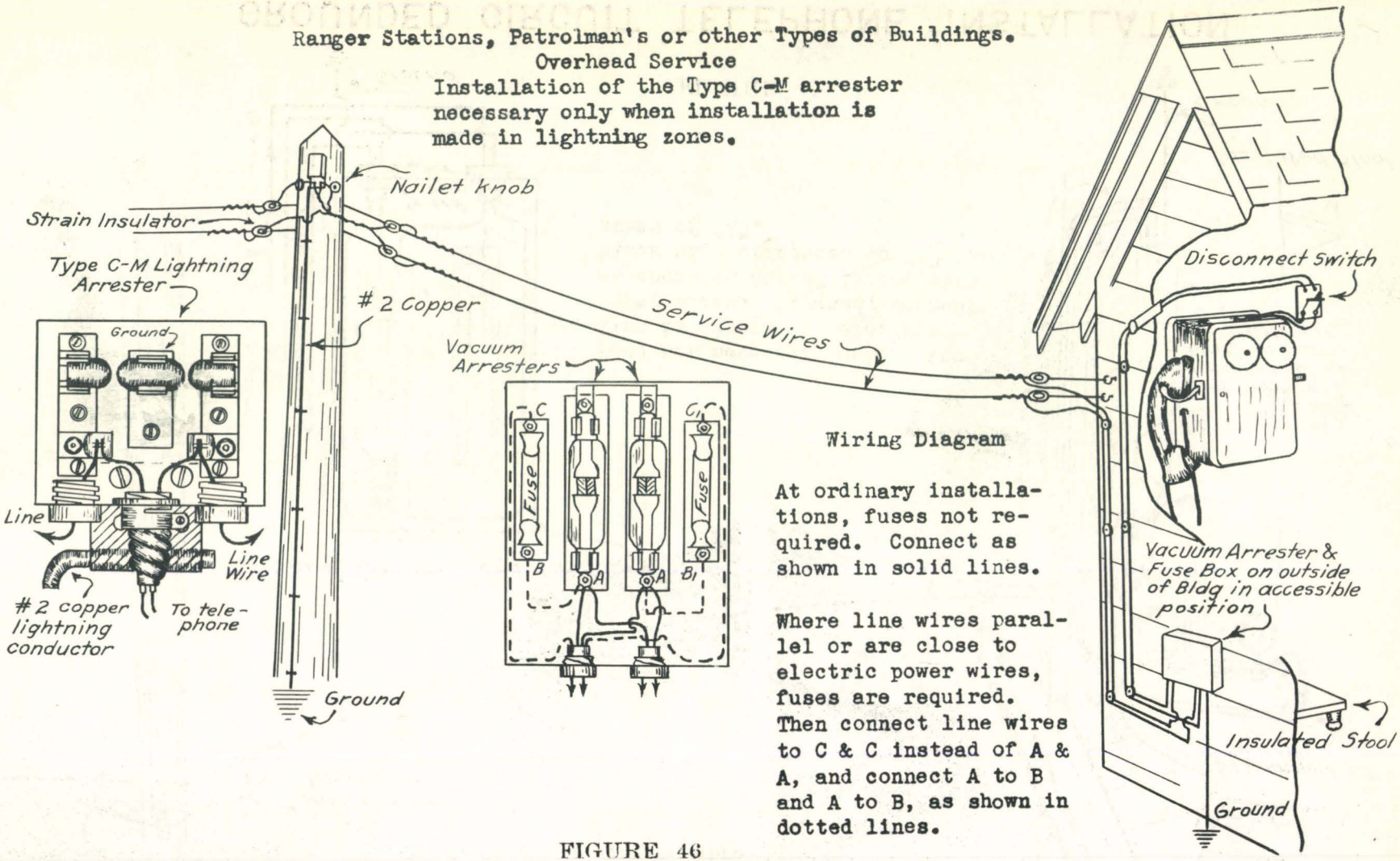


Fuse not necessary unless the line is exposed to electric power wires. If used, connect as shown in dotted lines, with black wire connected to "B" instead of "A".

FIGURE 45

GROUNDED CIRCUIT TELEPHONE INSTALLATION

Ranger Stations, Patrolman's or other Types of Buildings.
Overhead Service
Installation of the Type C-M arrester necessary only when installation is made in lightning zones.



Wiring Diagram

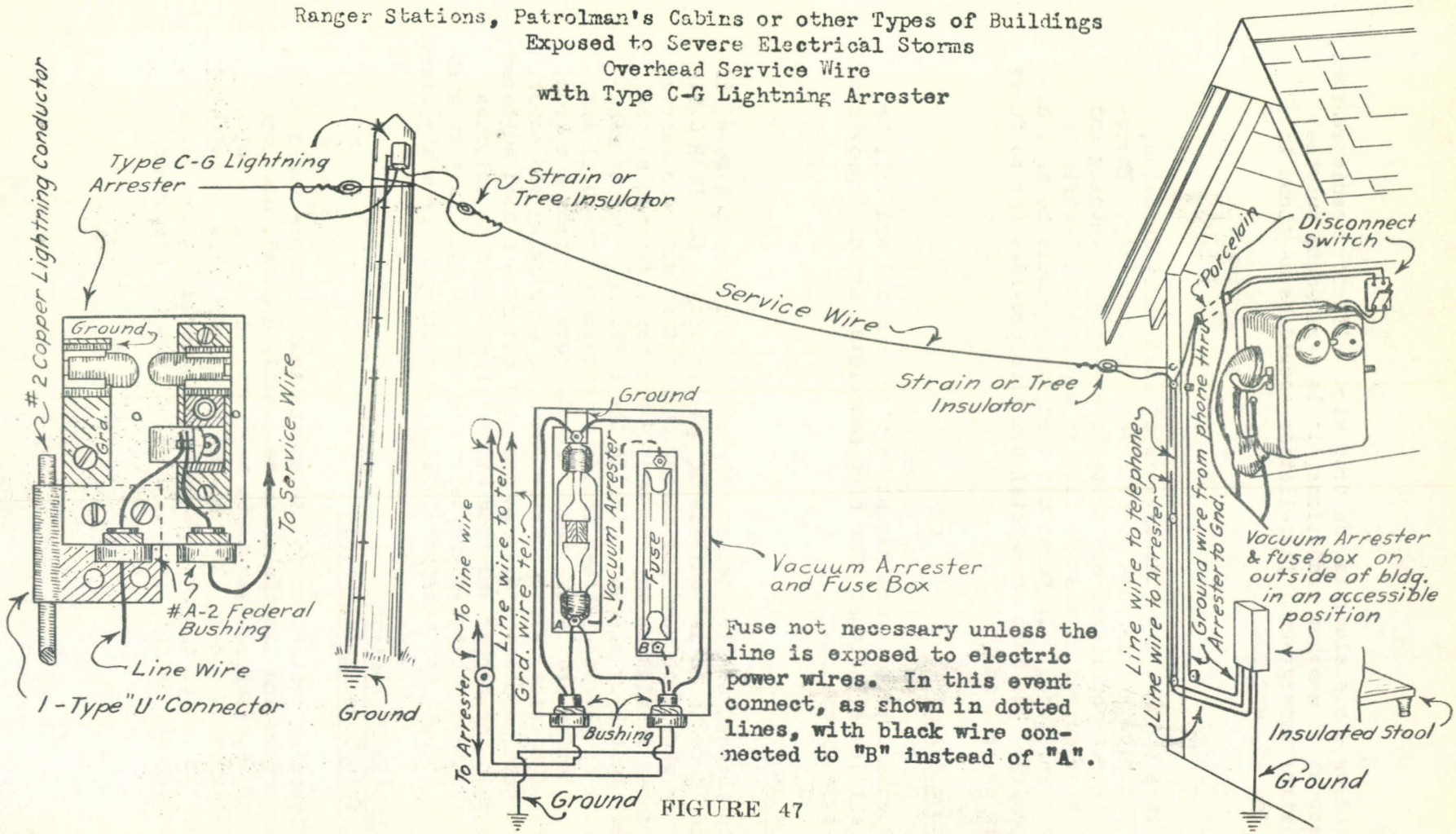
At ordinary installations, fuses not required. Connect as shown in solid lines.

Where line wires parallel or are close to electric power wires, fuses are required. Then connect line wires to C & C instead of A & A, and connect A to B and A to B, as shown in dotted lines.

FIGURE 46

METALLIC CIRCUIT TELEPHONE INSTALLATION

Ranger Stations, Patrolman's Cabins or other Types of Buildings
Exposed to Severe Electrical Storms
Overhead Service Wire
with Type C-G Lightning Arrester



Fuse not necessary unless the line is exposed to electric power wires. In this event connect, as shown in dotted lines, with black wire connected to "B" instead of "A".

FIGURE 47

GROUNDED CIRCUIT TELEPHONE INSTALLATION

care to allow ample slack in the drop wire. If, for scenic reasons, or on account of weather conditions, it is desired to put the service wires underground, installation should be as shown in figures 48, 49, and 50.

39. Line Fuses:

Since a lightning discharge is of such short duration, it will not blow a line fuse of even very low capacity. Therefore, it is not considered any protection against lightning and will not be required unless the line is exposed to electric light or power lines. If fuses are used, they should be of 7 ampere capacity. The best commercial practice provides for no fuses for cable protection.

40. Vacuum Arresters:

Vacuum arresters are Forest Service standard and will be used at all installations. The best commercial standard provides for air-type arresters.

41. Wiring:

On account of fire hazard, the vacuum arrester and fuse, if used, should be installed outside of the building. No. 14 R.C.S.B. copper wire should be used for making connections with the service wire as shown in figures 45, 46, and 47 and for extending to the disconnect switch or telephone inside the building. Do not make connections in the wire either inside or outside of the building without soldering and taping them. If the service wires are iron, some form of a solderless connector, such as a bridging connector, should be used, since the average man will not make a good soldered joint between the copper and iron wires. Disconnecting switches should be installed between the telephone and the line so that when the switch is out, the telephone will be disconnected from the line.

42. Lightning Protection for Telephone Installations:

Lightning protection for telephone installations includes vacuum arresters and line fuses to be installed at all stations. In addition, a discharge gap is to be installed at all installations in lightning zones. This is the principal "line of defense" and should be put on the nearest pole as shown in figures 46, 47, and 49. Suggestions for installations without the discharge

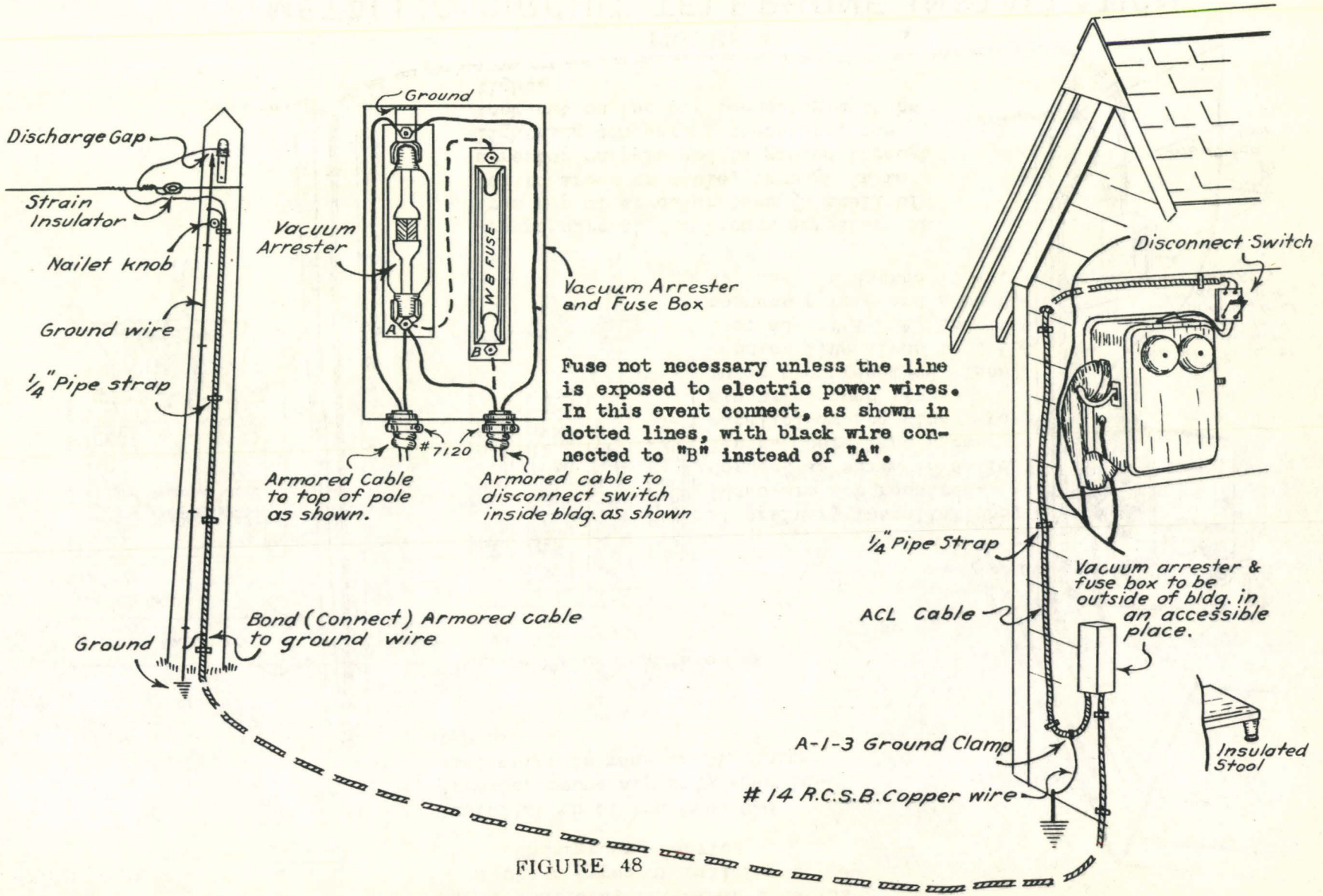
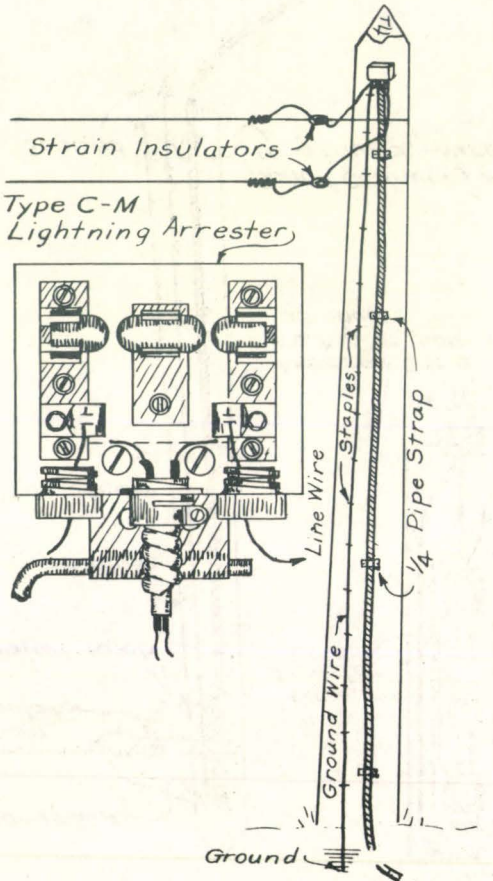


FIGURE 48

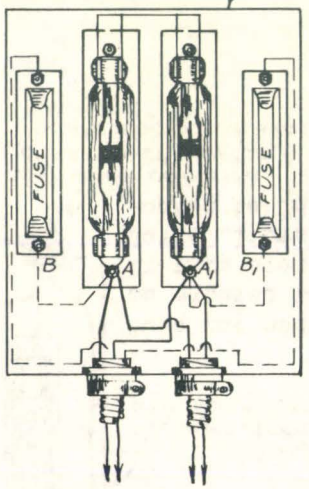
GROUNDED CIRCUIT TELEPHONE INSTALLATION

Ranger Stations, Patrolman's Cabins or other types of buildings. Underground Service

Installation of the Type C-M Arrester necessary only when installation is made in lightning zones.



Vacuum Arrester & Fuse Box Wiring Diagram



At ordinary installations, fuses are not required. Connect as shown in solid lines. Where line wires parallel or are close to electric power lines, fuses are required. Then connect line wires to C & C instead of A & A, and connect A_1 to B_1 and A to B, as shown in dotted lines.

Ground circuit for Vacuum Arresters is from top of arrester through shell of box to armor on cable, through it to arrester on pole and to ground through lightning conductor; therefore, the lock nut on the box connector must be tight.

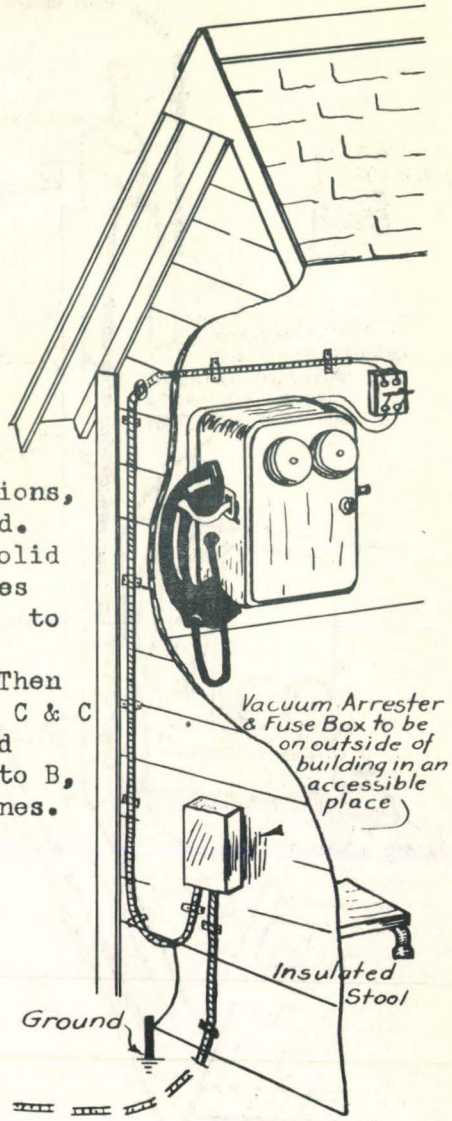


FIGURE 49

METALLIC CIRCUIT TELEPHONE INSTALLATION

Ranger Station, Patrolman's Cabin, or other Types of Buildings
Exposed to Severe Electrical Storms
Underground Service
Using Type ACL, #14 two-conductor armored cable.

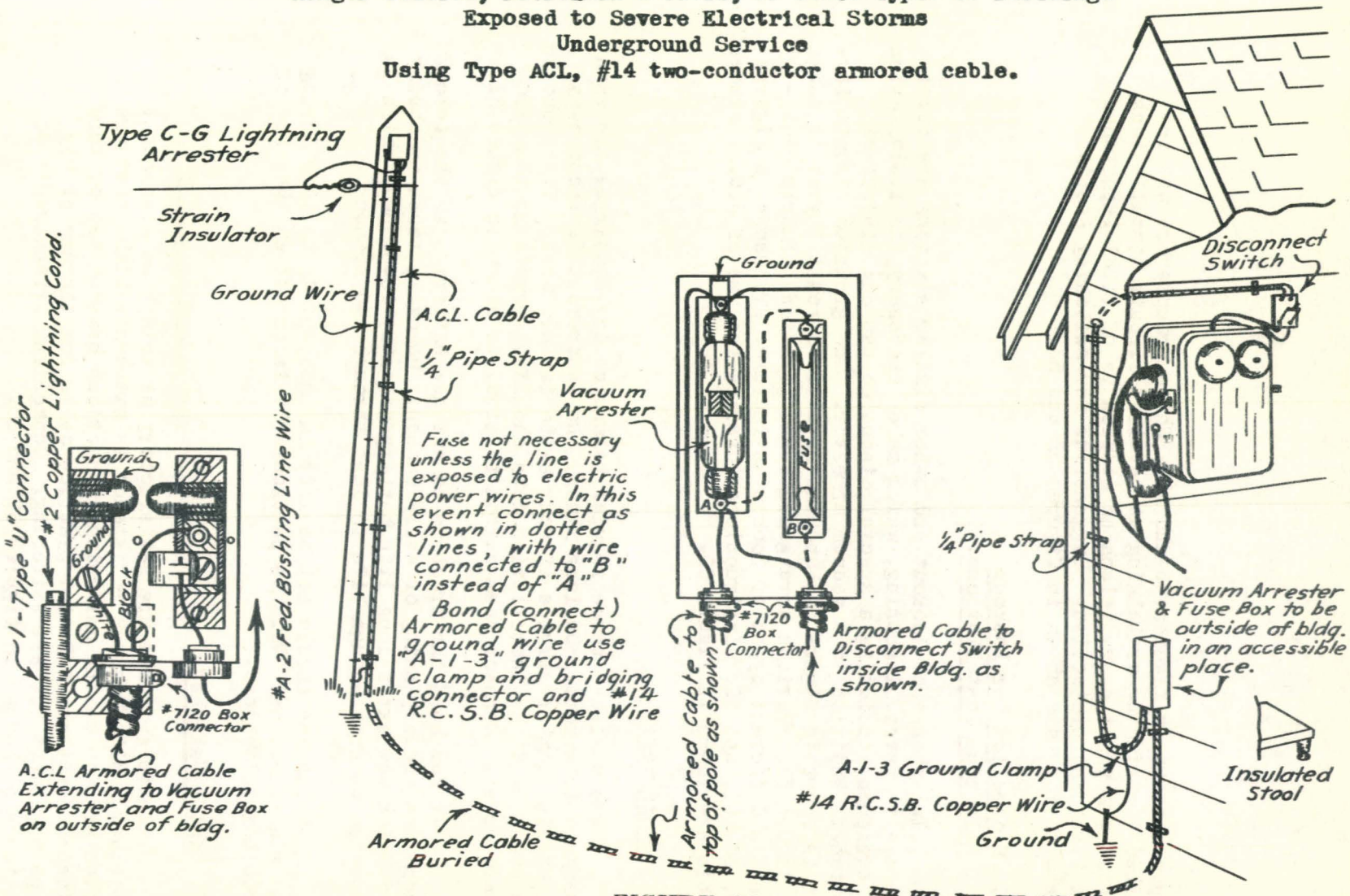


FIGURE 50

GROUNDED CIRCUIT TELEPHONE INSTALLATION

gap are shown in figures 45 and 48. While grounds are not required for ringing or talking at metallic circuit installations, a good ground at every telephone station is of vital importance for lightning protection. Suggestions for switching station installations are shown in figures 52 and 53.

43. Protection for Lookout Telephone Installations:

Telephones at lookout and other similar stations are often exposed to severe lightning, which makes necessary the installation of equipment including a special discharge gap and disconnect switch in addition to a vacuum arrestor. The grounded circuit layout is shown in figure 54, and the metallic circuit layout is shown in figure 55. Various arrangements and locations of this equipment in different types of lookout structures are shown in figures 56, 57, 58, and 59. Instructions covering the use of A.C.L. armored cable are shown in figure 60.

44. Batteries:

Use at least three regular telephone dry batteries for each standard telephone. On long lines, the instrument farthest away might give better service if four batteries are used. These should be fresh, and the installation date should be marked on the cardboard cover. Connect them carbon to zinc, as shown in figure 61.

It has been the practice to put new batteries in the telephones at the beginning of every season. However, tests are being made of a new extra long life battery recently developed, which is expected to have enough life to last through two seasons.

Batteries should not be left in unoccupied stations during the winter months. This is particularly important in the case of iron box telephones.

45. Knife Switches:

Knife switches are satisfactory as telephone disconnect switches. Although the resistance is extremely high, they are often used in making switching connections between two or more lines at stations. Better practice calls for the use of key type equipment for all switching. Convenient arrangements of switches are shown in figures 62 and 63.

Telephone grounds must be made in soil that is a good conductor. Soil that has in it considerable humus, as will be found in marshy ground, adjacent to a cesspool, or that receives waste water from a sink or camp, contains both the moisture and electrolyte necessary to make it a good conductor.

Eighty percent of the resistance of a ground is in the soil within 6 or 8 feet of the ground electrode.

The diameter or surface area of an electrode has little to do with the ground resistance.

A galvanized iron water pipe, two or three hundred feet long, buried in soil as above described, usually makes a good ground. Use a regular ground clamp for making connection with it.

Following are instructions for making a ground when a water pipe is not satisfactory or is not available:

1. Copper makes the best ground electrode,-either a copper wire about 8' long, No. 2 or No. 4 B & S gauge, or a $\frac{1}{2}$"x6" copper covered ground rod. Galvanized iron rods $\frac{1}{2}$" x 8' are used commercially and have a useful life of from 5 to 10 years.

2. When it is necessary to make a ground in soil that does not contain moisture and an electrolyte as described above, salt must be added. Rock salt contains more calcium chloride than ordinary salt and will last longer. If this is not available, use stock salt. Use about 50 lbs., applied in a circular trench near the surface of the ground, as shown in the diagram, taking care to keep the salt from coming in direct contact with the ground rod. In dry soil, add water occasionally, and renew the salt every two or three years.

3. If one ground does not give satisfactory results, a second ground made not less than 9 or 10 feet away, will usually lower the resistance from 30 to 40%. In very dry soil 3 or 4 electrodes, separated as above, may be necessary. In every case where more than one electrode is used, they should all be connected together.

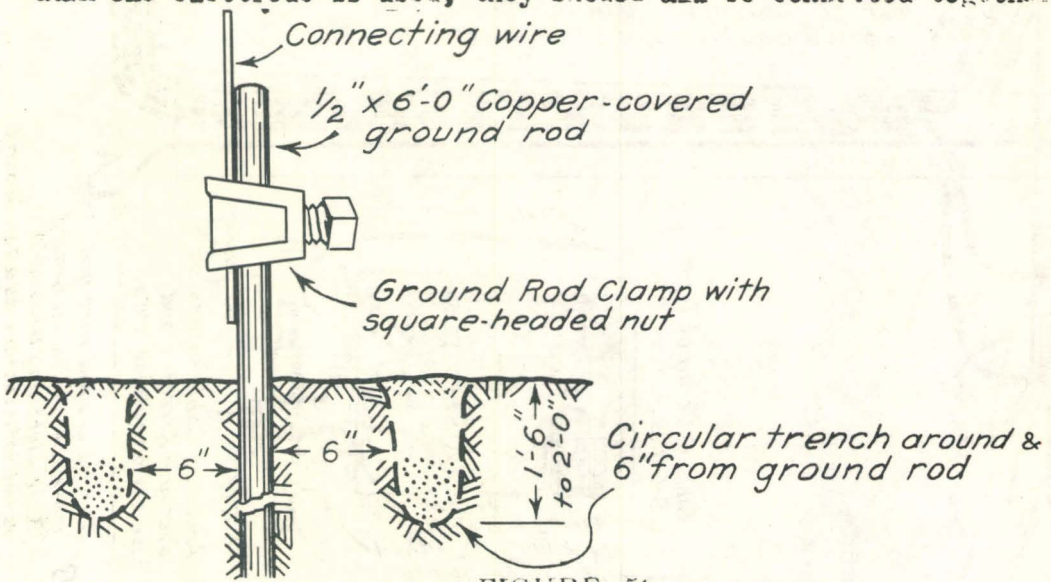
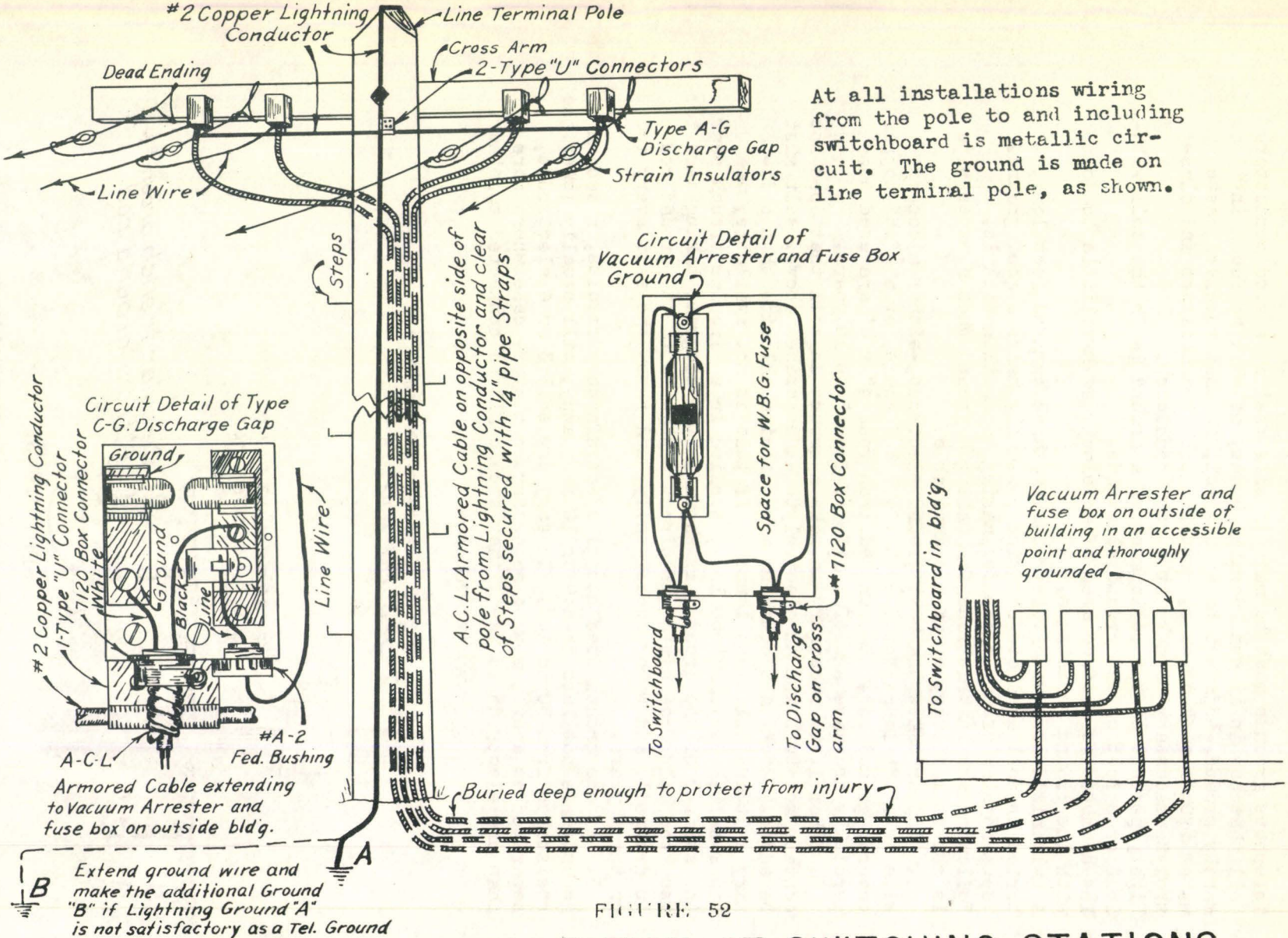


FIGURE 51

TELEPHONE GROUNDS



At all installations wiring from the pole to and including switchboard is metallic circuit. The ground is made on line terminal pole, as shown.

FIGURE 52

TELEPHONE INSTALLATION AT SWITCHING STATIONS

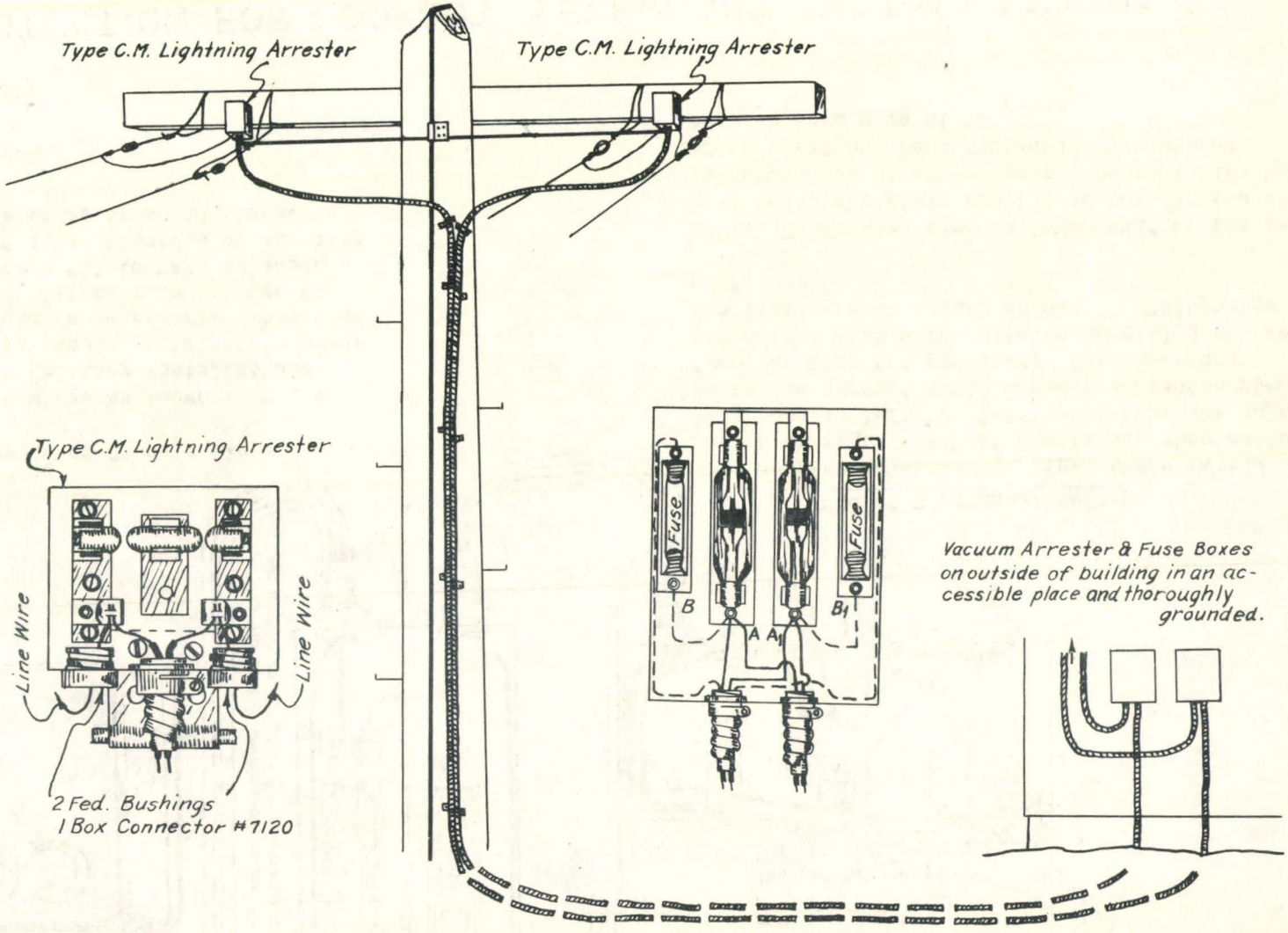
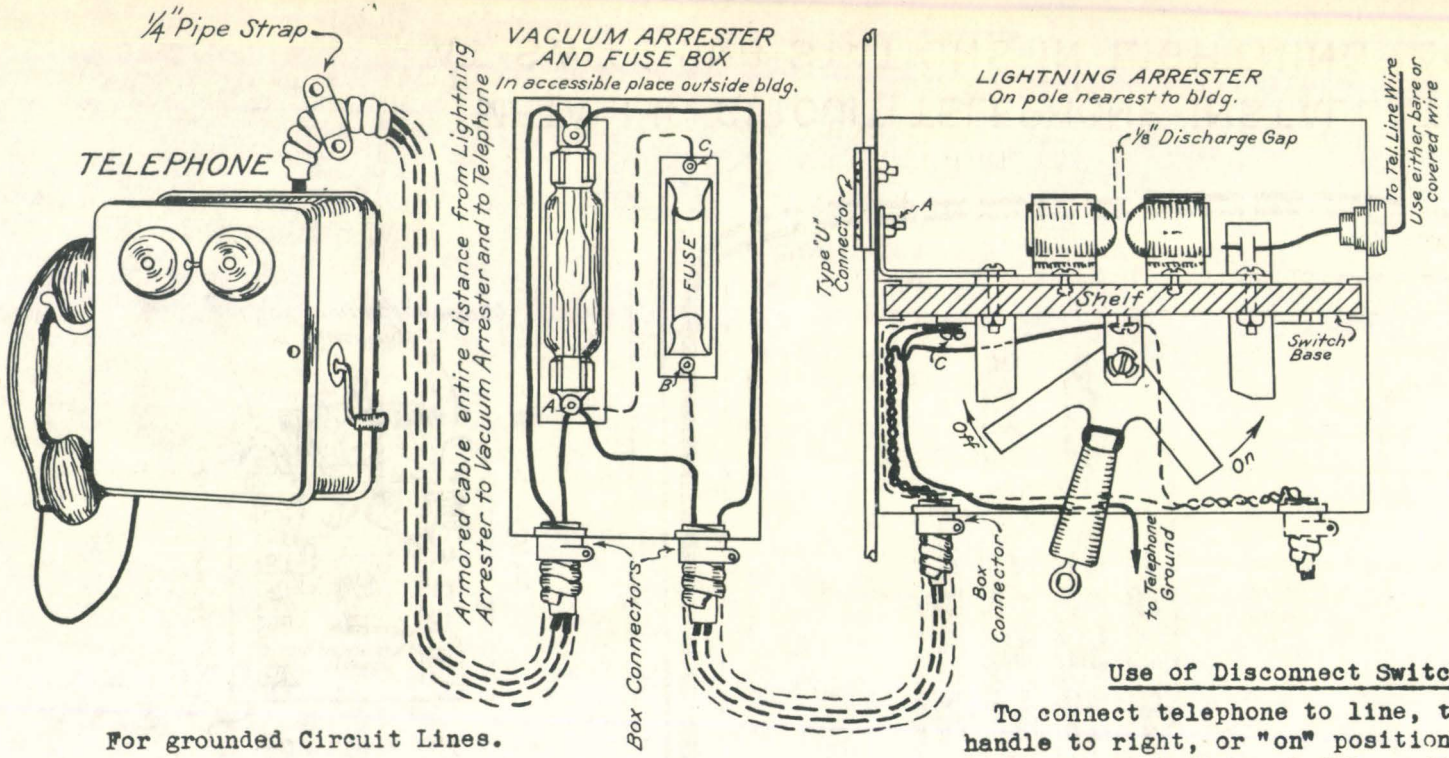


FIGURE 53

METALLIC CIRCUIT TELEPHONE INSTALLATION
AT SWITCHING STATIONS IN LIGHTNING ZONES



For grounded Circuit Lines.

Connect wires as shown in solid lines for ordinary installations. If line is exposed to electric power wires, fuse is necessary. Then connect black (line) wire to fuse at "B" and from "C" to "A", as shown by dotted lines, instead of directly to "A" as shown by solid lines.

Use of Disconnect Switch

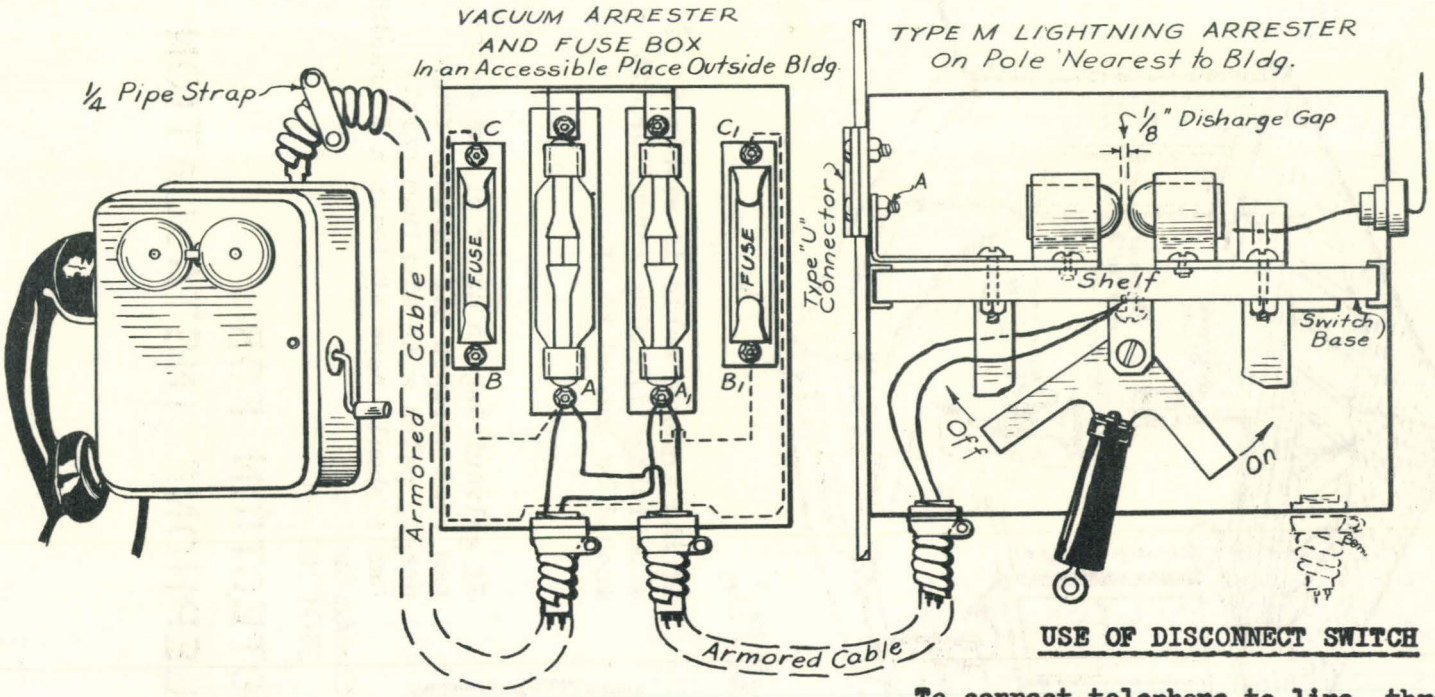
To connect telephone to line, throw switch handle to right, or "on" position. When switch is thrown to left, or "off" position, the telephone and armored cable wires are disconnected from the line and grounded. This does not ground the line wire. Lightning will jump from the line wire to ground across the "Discharge Gap".

NOTE: To connect wire in lower half of box remove bolt "A", slide shelf from box far enough to permit use of screwdriver. Connect line "L" after shelf has been replaced. Use washer between each wire at "C".

FIGURE 54

PROTECTION FOR LOOKOUT TELEPHONE INSTALLATIONS

Circuit Layout
For Metallic Circuit Lines



VACUUM ARRESTER & FUSE BOX

To be in an accessible place on outside of building. Connect as shown in solid lines when fuses not required. Where line wires parallel or are close to electric power wires, fuses are roquired. Then connect line wires to C & C instead of A & A_1 and connect A to B and A to B, as shown in dotted lines. Ground circuit for vacuum arresters through shell of box to armor on cable. The lock nut on the box connector must be tight.

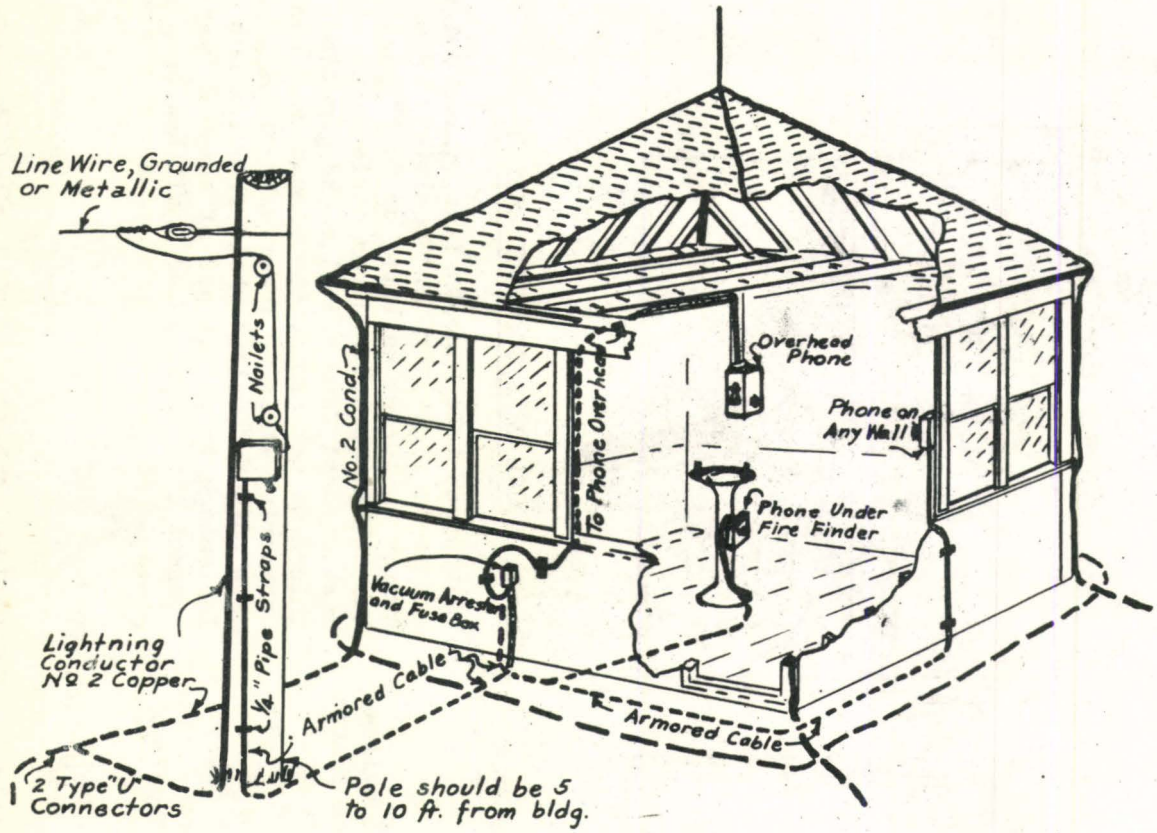
USE OF DISCONNECT SWITCH

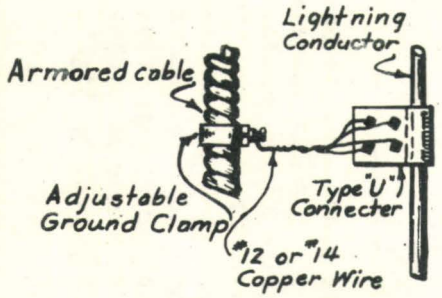
To connect telephone to line, throw switch handle to right, or "on" position. When switch is thrown to left, or "off" position, the telephone and armored cable wires are disconnected from the line and grounded. This does not ground the line wire. When connecting wires in lower half of box, remove bolt "A", slide shelf from box out far enough to permit use of screw driver. Connect line wires after shelf has been replaced.

FIGURE 55

PROTECTION FOR LOOKOUT TELEPHONE INSTALLATION

Lookout House on the ground.
Either one grounded or metallic circuit line.





Bonding Armored Cable to Conductor

If the armored cable is within 6" of a building lightning conductor, it should be bonded to it.

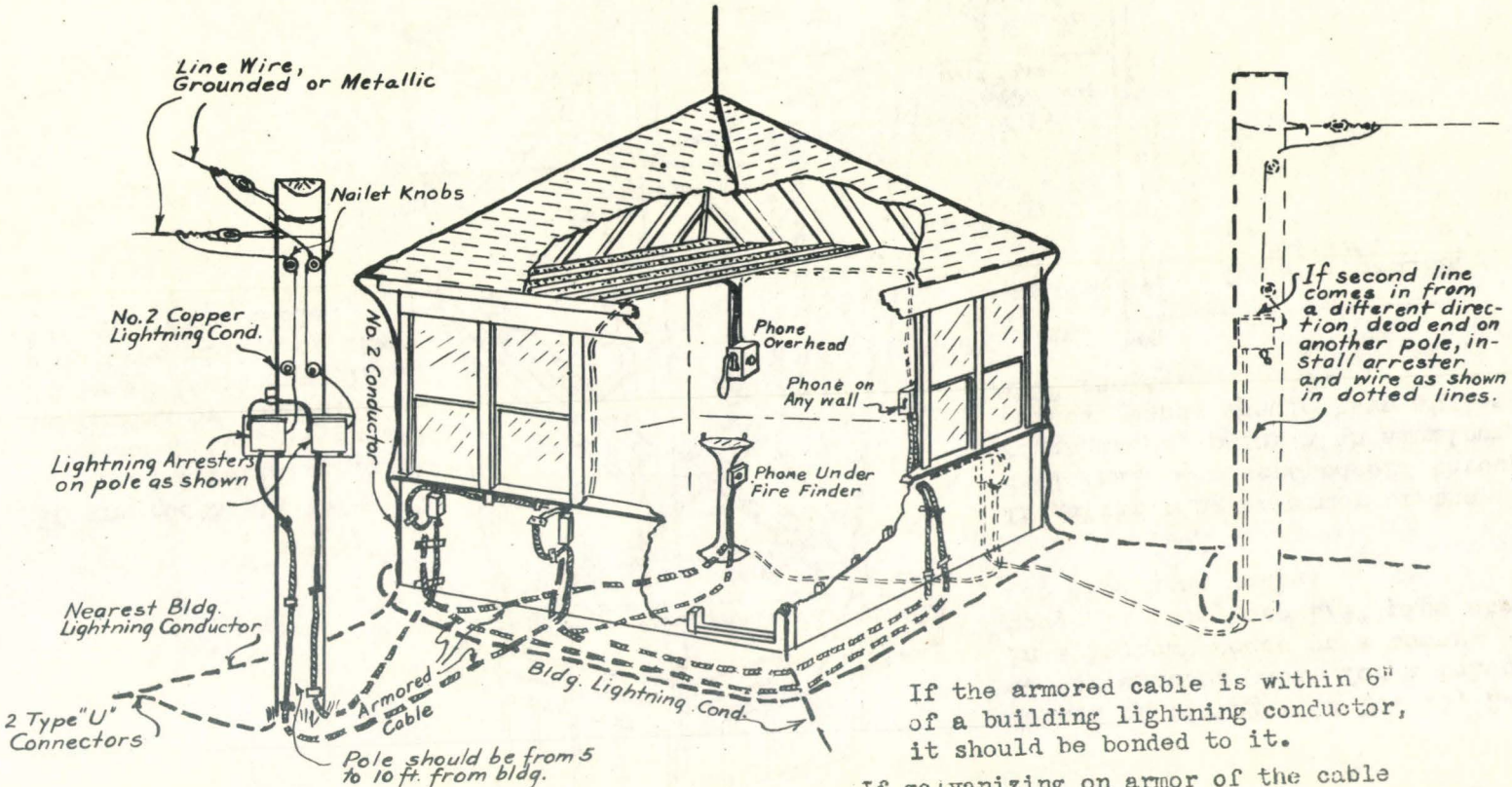
If galvanizing on armor of the cable has been scraped off through rough usage, paint with aluminum paint. Bends should have at least a 5" radius.

FIGURE 56

PROTECTION FOR LOOKOUT TELEPHONE INSTALLATION

Ranger Stations, Patrolman's Cabins or other types of buildings. Underground Service.

Method of wiring with No. 14, 2-conductor armored cable for a telephone located either on a side wall, on fire finder stand, or above fire finder stand.



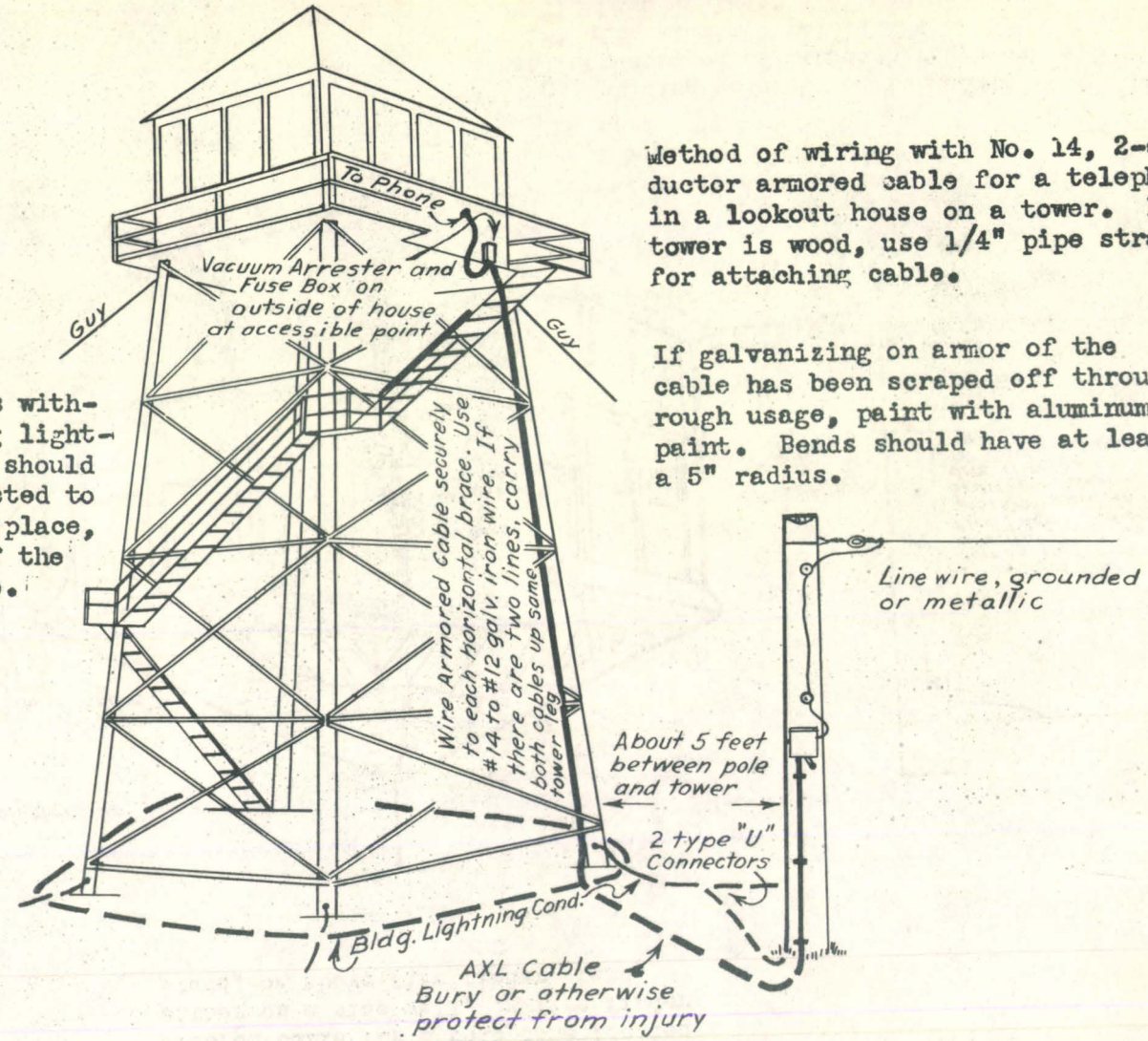
If the armored cable is within 6" of a building lightning conductor, it should be bonded to it.

If galvanizing on armor of the cable has been scraped off through rough usage, paint with aluminum paint. Bends should have at least a 5" radius.

FIGURE 57

PROTECTION FOR LOOKOUT TELEPHONE INSTALLATIONS

Lookout House on a Tower.
One or two grounded or metallic circuit line.



Method of wiring with No. 14, 2-conductor armored cable for a telephone in a lookout house on a tower. If tower is wood, use 1/4" pipe straps for attaching cable.

If galvanizing on armor of the cable has been scraped off through rough usage, paint with aluminum paint. Bends should have at least a 5" radius.

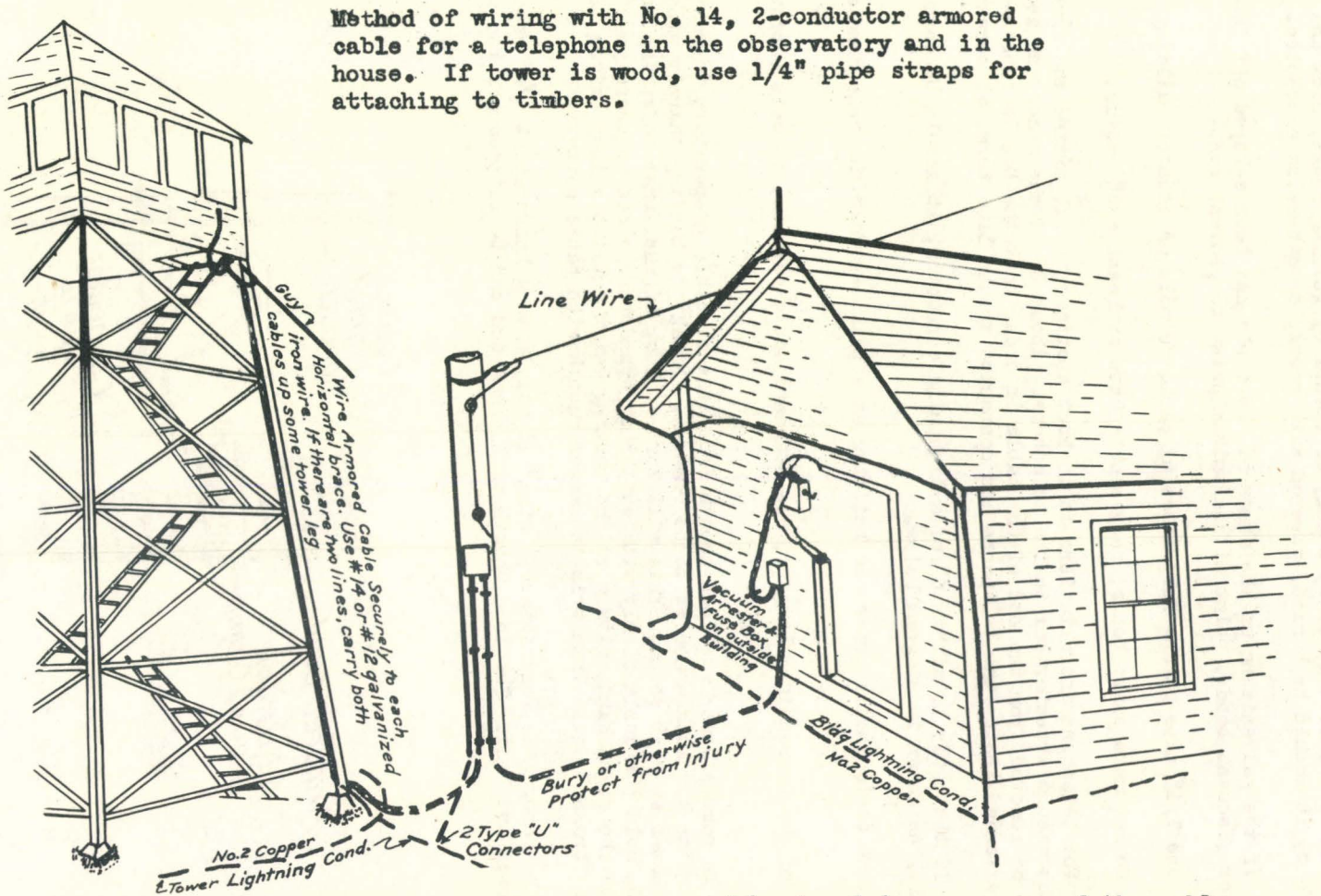
If armored cable is within 6" of a building lightning conductor, it should be bonded or connected to it in at least one place, about the middle of the length of the cable.

FIGURE 58

PROTECTION FOR LOOKOUT TELEPHONE INSTALLATIONS

Inclosed or open Observatory on a Tower with House on ground. One or two grounded or metallic circuit line.

Method of wiring with No. 14, 2-conductor armored cable for a telephone in the observatory and in the house. If tower is wood, use 1/4" pipe straps for attaching to timbers.



If the armored cable is within 6" of a building lightning conductor, it must be bonded to it, as shown.

If galvanizing on armor of the cable has been scraped off through rough usage, paint with aluminum paint. Bends should have at least a 5" radius.

FIGURE 59

PROTECTION FOR LOOKOUT TELEPHONE INSTALLATIONS

INSTRUCTIONS FOR THE USE OF ARMORED CABLE

The cable may be injured if placed where it will be walked on by persons with hobbed or calked boots, or trod on by stock, or struck by rolling rocks, pick and shovel, etc.; therefore, it should be buried, covered with rocks, or otherwise protected.

If the galvanizing on the armor of the cable has been scraped off through rough usage or frequent bends, paint with aluminum paint to prevent rust.

Use 1/4" pipe straps for fastening cable to pole or side of buildings, etc.

Do not make sharp bends; they should have at least a 5" radius.

For telephone installations in lookout stations, etc., extend the armored cable from the vacuum arrester box to the telephone. About 8" of the armor and lead sheath will need to be removed from the end of the cable in order that the No. 14 rubber-covered wire can be extended inside the telephone and connected to the line terminal screws.

If the cable is within 6" of a lightning conductor, it should be connected (bonded) to it, as shown in diagram below.

The cable should enter the building at a point as near the telephone as possible.

To cut in required lengths, use standard cable cutters, or bolt cutters, or hacksaw.

To remove armor and lead sheath from ends of cable preparatory to making connection, determine how much armor is to be removed, "break" by bending sharply with pressure of both hands at that point. This will force a loop of the armor to spring out. With the left hand, hold the cable firmly with cutter or connectors close to where you "broke" it. Then with the right hand, give a slight turning twist until the loop raises in the loop of armor "broken" out. Then trim the armor smooth with cable cutters.

To remove the lead sheath, "ring" lightly with a knife about 1/4" beyond the end of the armor and bend. The lead sheath will break and can be slipped off the wire easily.

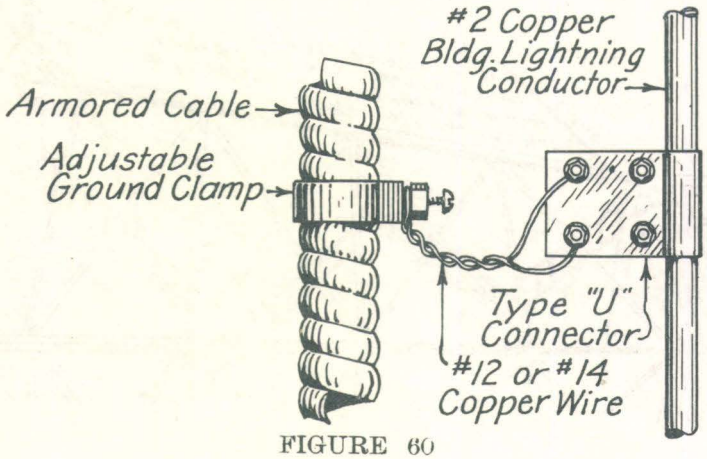


FIGURE 60

USE OF ARMORED CABLE

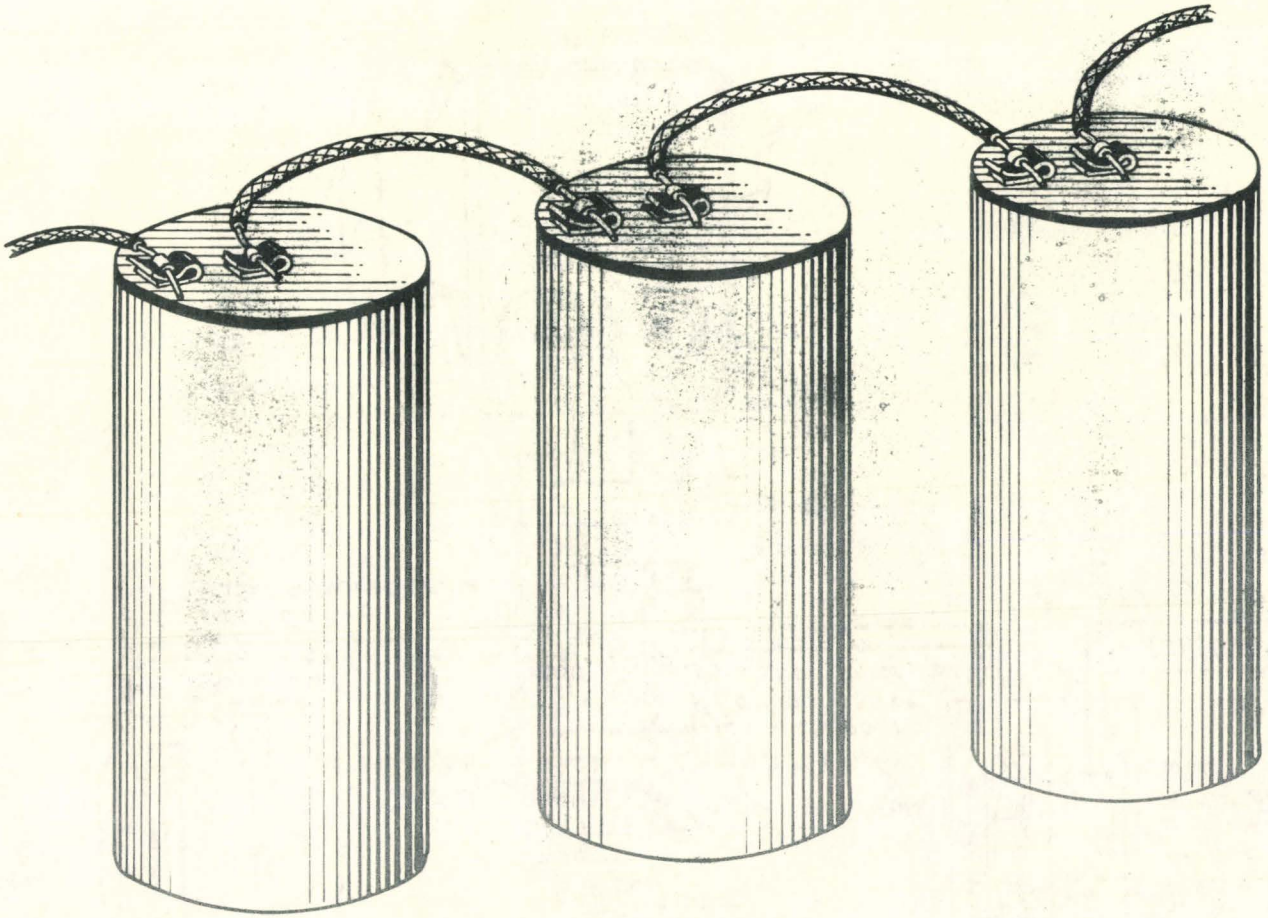


FIGURE 61

METHOD OF CONNECTING DRY BATTERIES

For Lookout Telephone Installations
for two Lines.

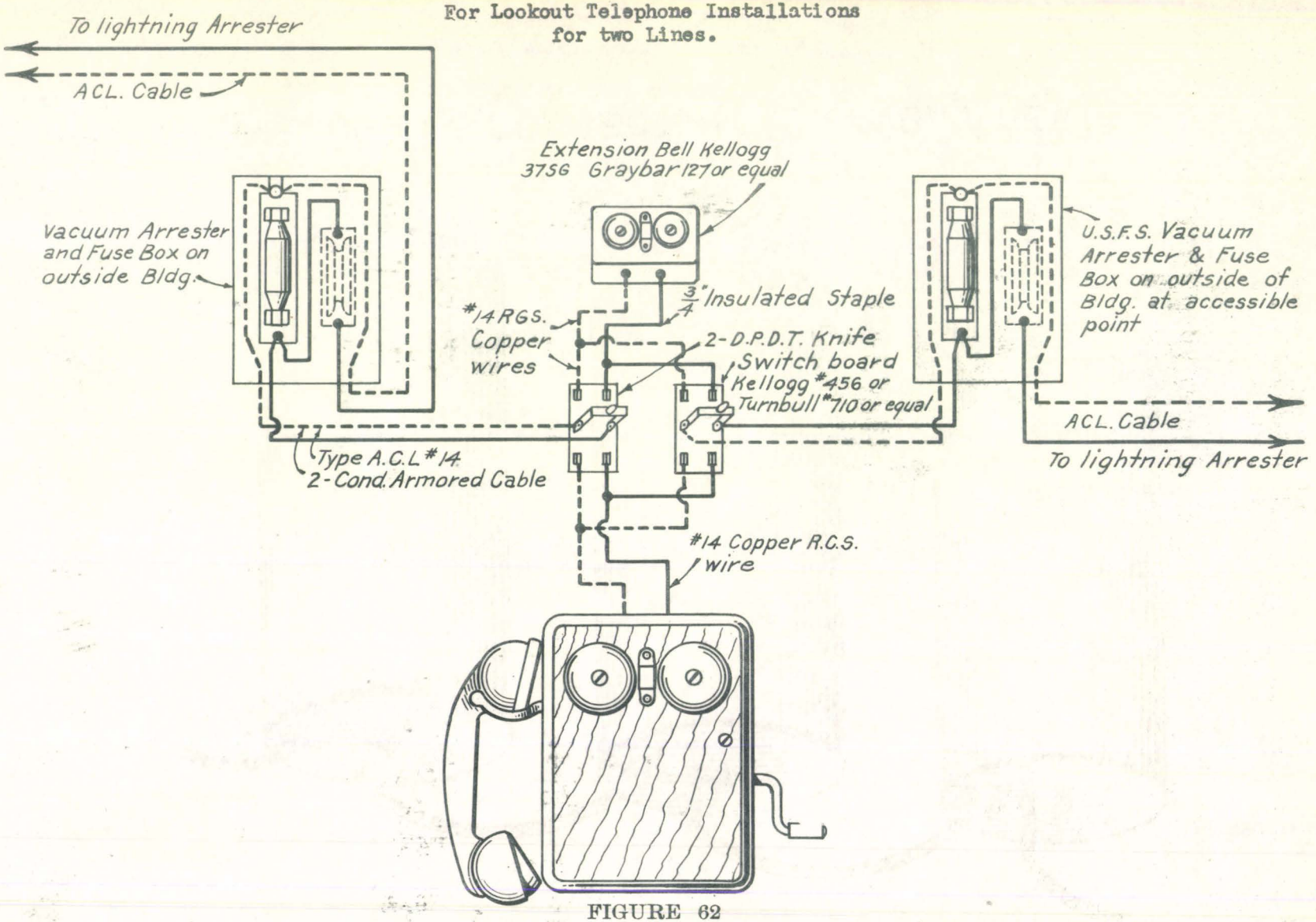


FIGURE 62

KNIFE SWITCHBOARD

For Lookout Telephone Installations
for three Lines

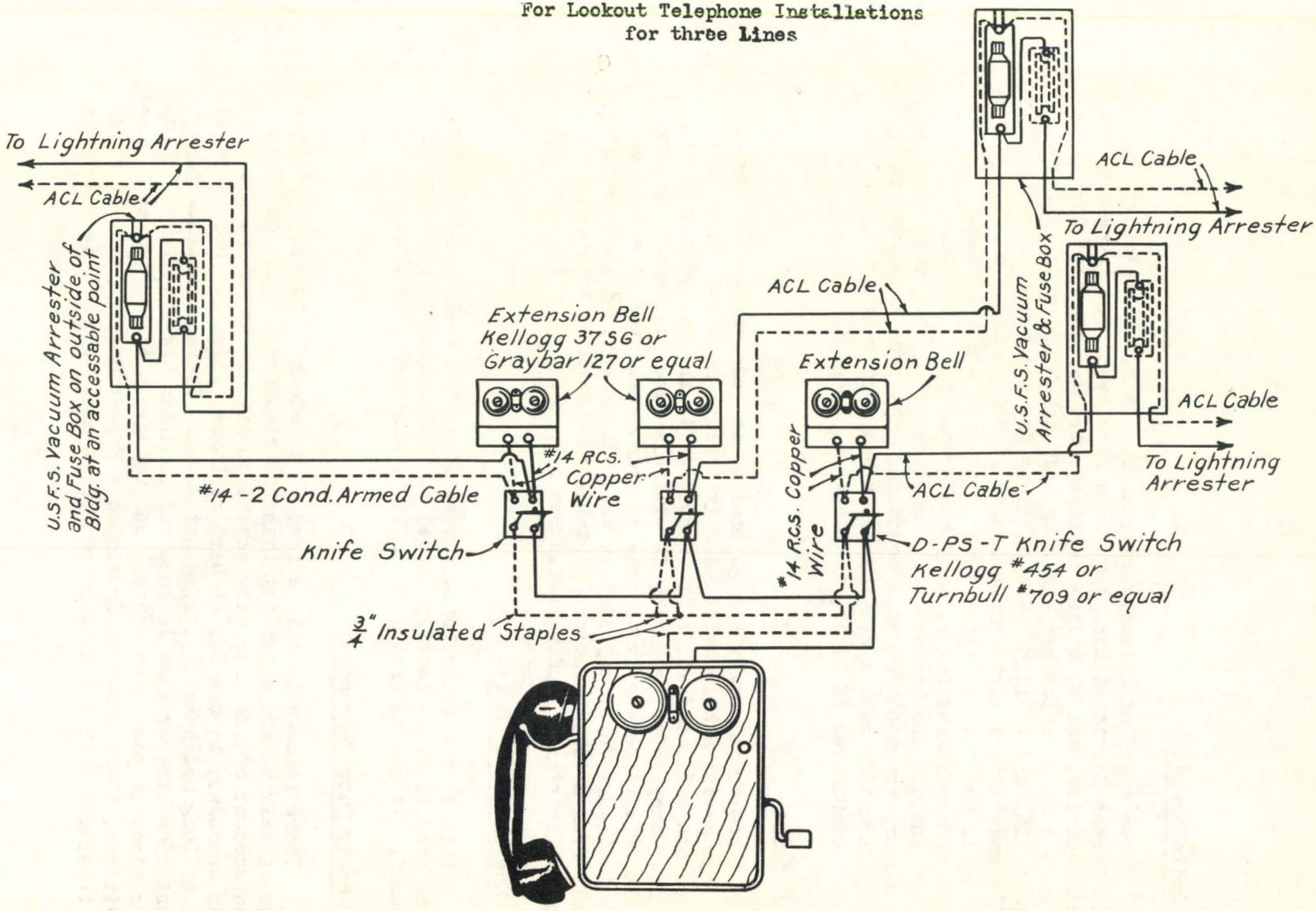


FIGURE 63

KNIFE SWITCHBOARD

46. Switchboards:

Three types of switchboards, A, B, and E, satisfactory for use on Forest Service lines, have been developed. The type A, 6 line capacity, and B, 9 line capacity, are key boards. The type E is a combination key and plug and jack board made in three sizes 12, 18, and 24 line. The cabinets for the boards contain all the switchboard parts and are made in Models 5 and 6. The Model 6, in addition to keys, ringers (bells) etc., includes howlers and equipment for sending howler signals. The Model 5 does not include the howlers and signaling set. Both the A and B boards are for table or wall mounting. The type E cabinet is for wall mounting with space for cords and cord weights to hang below. See figures 64 to 75, inclusive.

47. Howlers:

A howler is merely a high resistance receiver with a special diaphragm having a horn attached. It is much more sensitive than a telephone bell, and while it is more efficient for receiving the high frequency howler signals, it will also receive very weak ring signals. It is necessary to have a howler connected to a line as shown in figure 76 at any station where it is desired to receive signals from a light aluminum portable telephone or from the large howler signal sending set. See figure 77.

48. Howler Signal Set:

This is a set developed for sending loud howler signals for use on long lines so heavily loaded that ring signals may not "go through". It can be used only on lines equipped with howlers.

49. Heavy Duty Telephone:

There is occasionally a need of a telephone having a greater range of talking and receiving than the standard telephone. This is on account of the unusually severe conditions under which it is often necessary to use Forest Service lines, which frequently consist of long and heavily loaded net works. There is an excessive amount of static or line leakage and considerable interference from other electric power, telephone, and telegraph lines. To meet these conditions, there has been developed a Forest Service type of desk set telephone with a double microphone transmitter. This telephone

INSTALLATION AND OPERATING INSTRUCTIONS

for

Type A Switchboard
Either Model 5 or Model 6

Line wires enter the switchboard cabinet through holes in the back and are connected to the proper binding screws in the lower terminal strip, which is attached to the back of the equipment panel. It is customary to set the cabinet on a shelf or table and to fasten in place with small angle irons attached to the outside of the cabinet, after line wires are connected.

Each line is connected to a key (with black handle) also to a bell (and howler, if used).

The operator's telephone including the magneto is connected to the left hand, or operators key (with white handle).

The howler signal set, if installed, is connected to the operators telephone circuit, through the right hand key. This key has a red handle, and operates only in one way and is self-restoring.

To talk or ring on a line, pull the operators key together with the line key in the same direction, either up or down.

To connect two or more lines together, which are either grounded or metallic circuit, pull the corresponding numbered line keys in the same direction, either up or down.

To connect grounded circuit and metallic circuit lines together, pull the corresponding line keys up. This cuts the repeat coil in circuit.

To send a howler signal on a line, pull both the line and operators keys in the same position, up or down, and push the key handle up intermittently to send proper signals, long or short, etc.

The push button disconnect switches are installed in order to permit the disconnecting of ringers and howlers on a line and thus eliminate their line load when it is desired to answer calls from an auxiliary switchboard at the station.

FIGURE 64

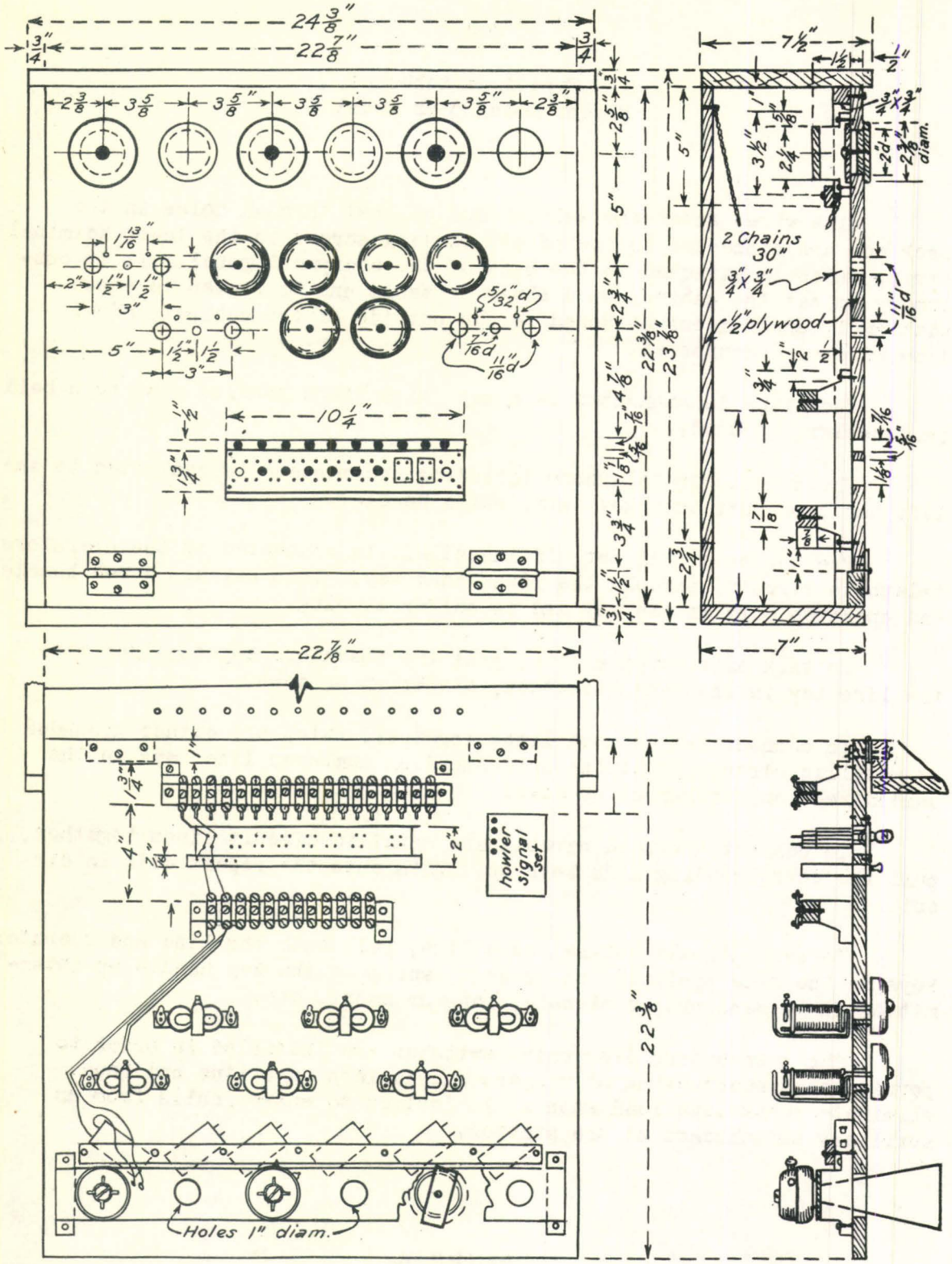


FIGURE 65

TYPE A MODEL 6 SWITCHBOARD

CABINET AND EQUIPMENT ASSEMBLY

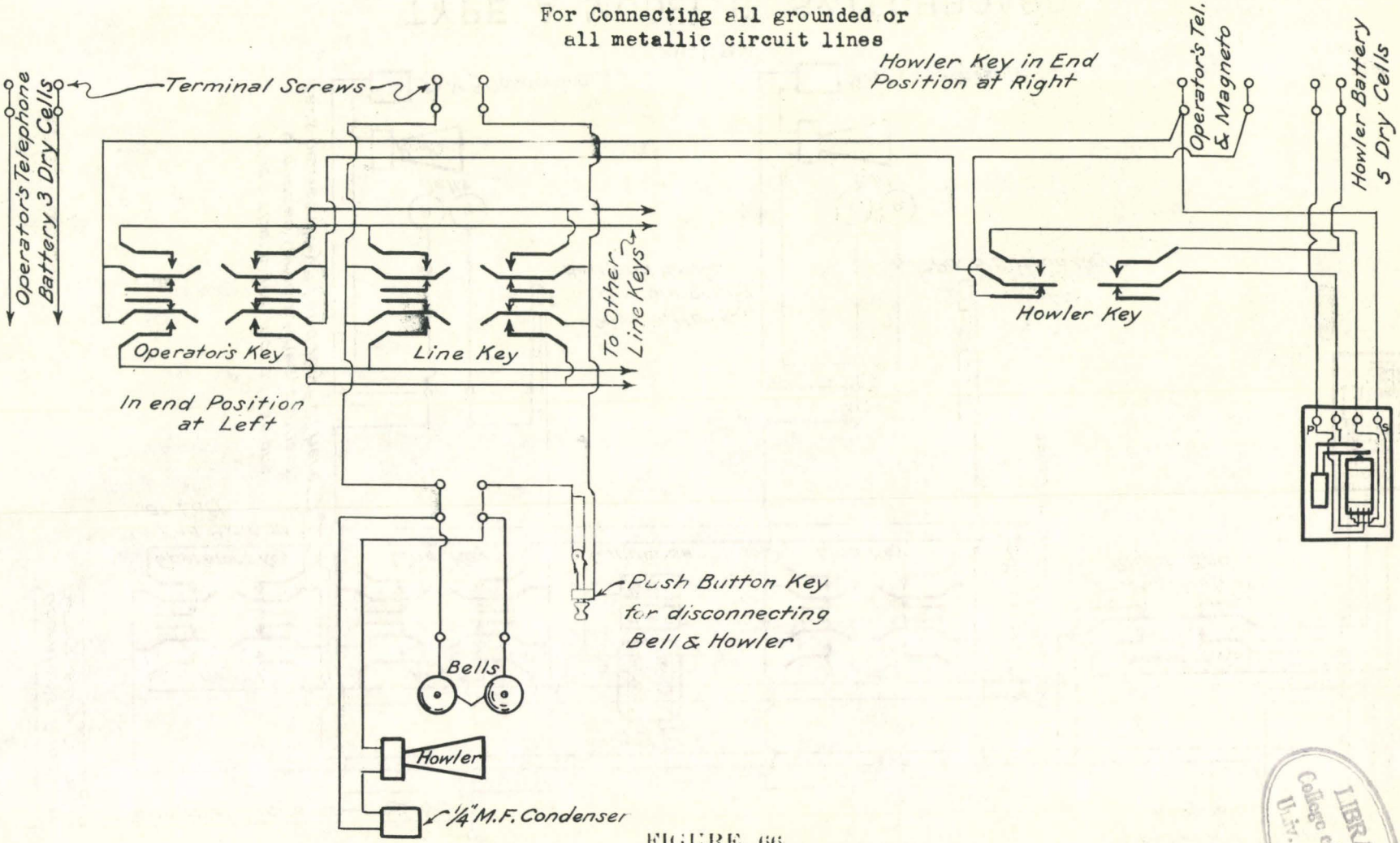


FIGURE 66

TYPE A MODEL 6 SWITCHBOARD
WIRING DIAGRAM

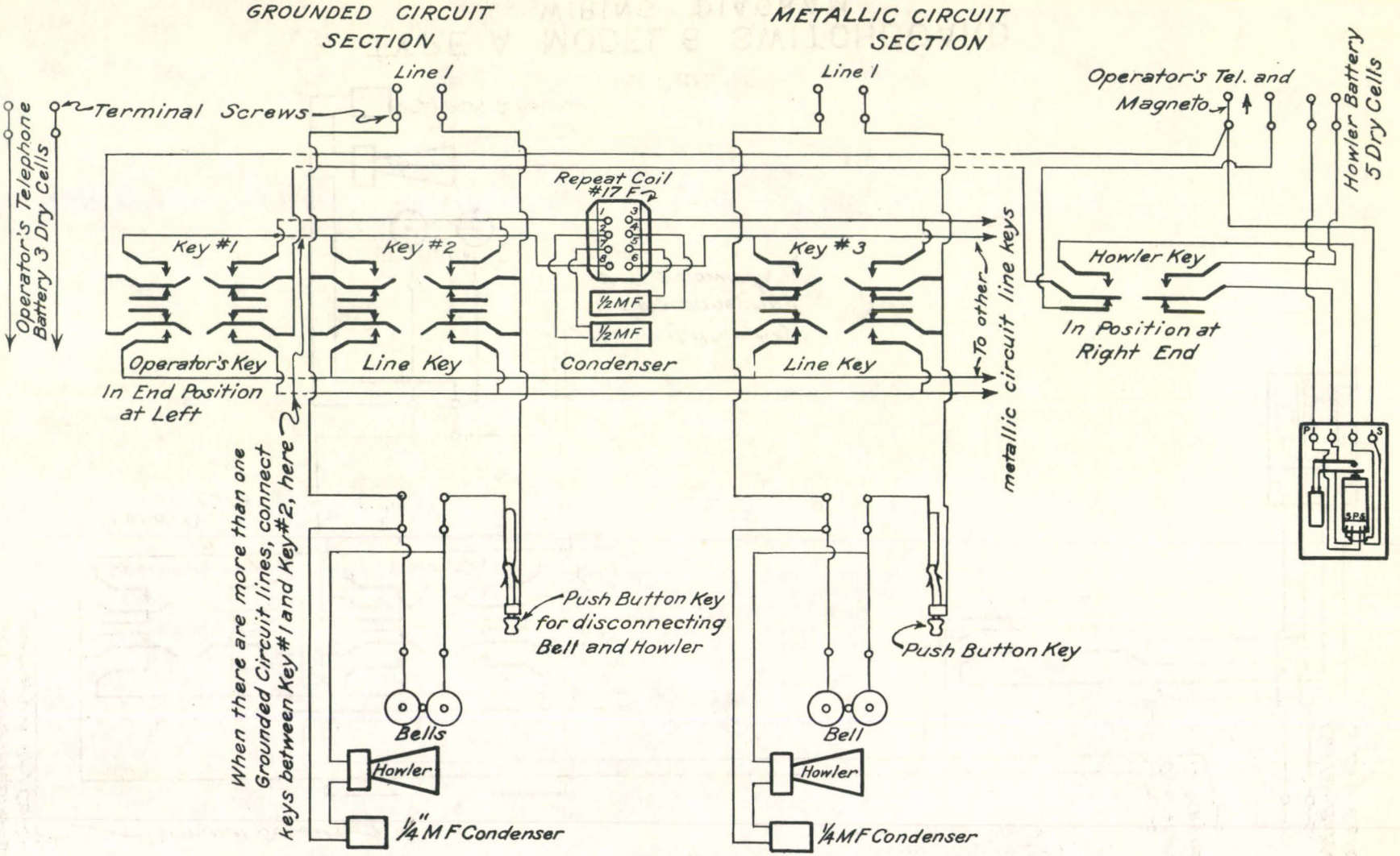


FIGURE 67

TYPE A MODEL 6 SWITCHBOARD
WIRING DIAGRAM

INSTALLATION AND OPERATING INSTRUCTIONS

for

Type B Switchboard
Either Model 5 or Model 6

Line wires enter the switchboard cabinet through holes in the back and are connected to the proper binding screws in the lower terminal strip, which is attached to the back of the equipment panel. It is customary to set the cabinet on a shelf or table and to fasten in place with small angle irons attached to the outside of the cabinet, after line wires are connected.

Each line is connected through the line operators key to the line switching key and to the corresponding numbered bell (and howler, if used).

Upper row of keys are line keys with black handles, and are used only for connecting lines together; there is one key for each line.

Lower row of keys, with white handles, are operators keys and are used for either talking or ringing on a line. There is one key for each line.

The howler signal set, if installed, is connected to a one way, non-locking key with a red handle, at the right in the lower row of keys.

To talk on a line, pull corresponding operators key down.

To ring on a line, hold corresponding operators key up, while ringing the desired code ring.

To connect two or more lines together, throw the corresponding line keys in the same direction, either up or down.

To send a howler signal on a line, hold corresponding operators key up, and at the same time pull the howler key up intermittently, to make proper signals, long or short, etc.

The push button disconnect switches are installed in order to permit the disconnecting of ringers and howlers on a line and thus eliminate their line load when it is desired to answer calls from an auxiliary switchboard at the station.

FIGURE 68

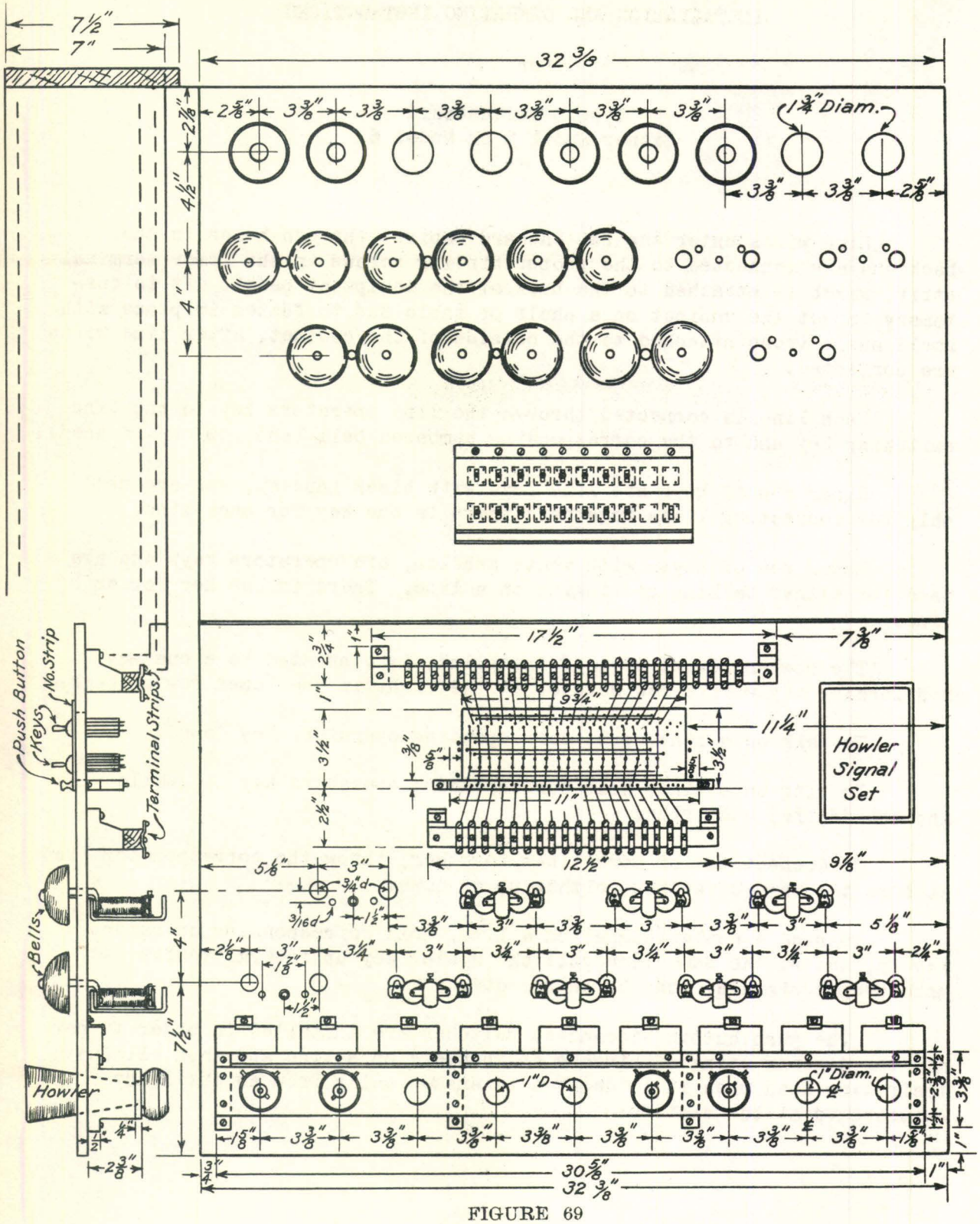


FIGURE 69

TYPE B MODEL 6 SWITCHBOARD
CABINET AND EQUIPMENT ASSEMBLY

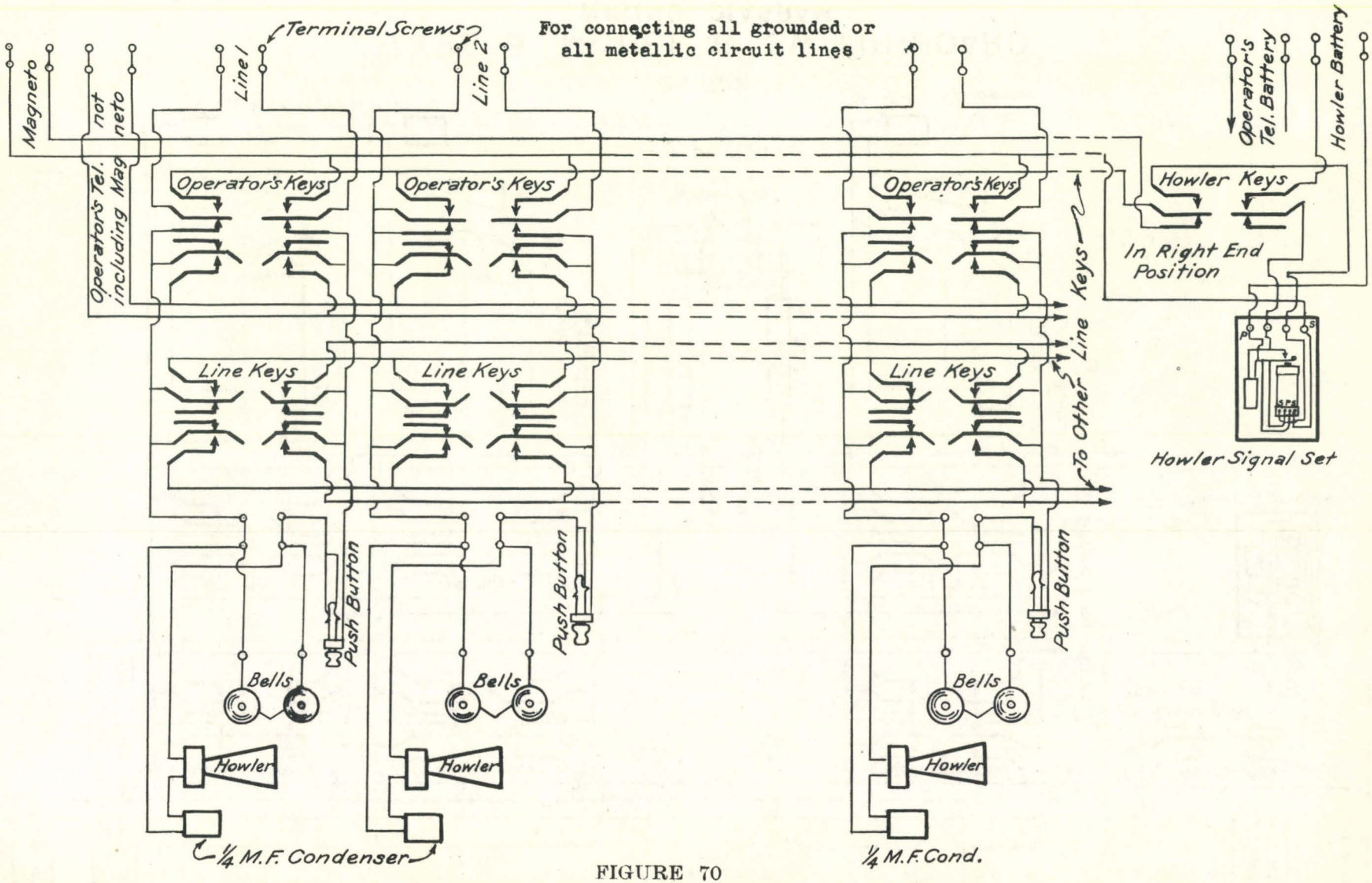


FIGURE 70

TYPE B MODEL 6 SWITCHBOARD
WIRING DIAGRAM

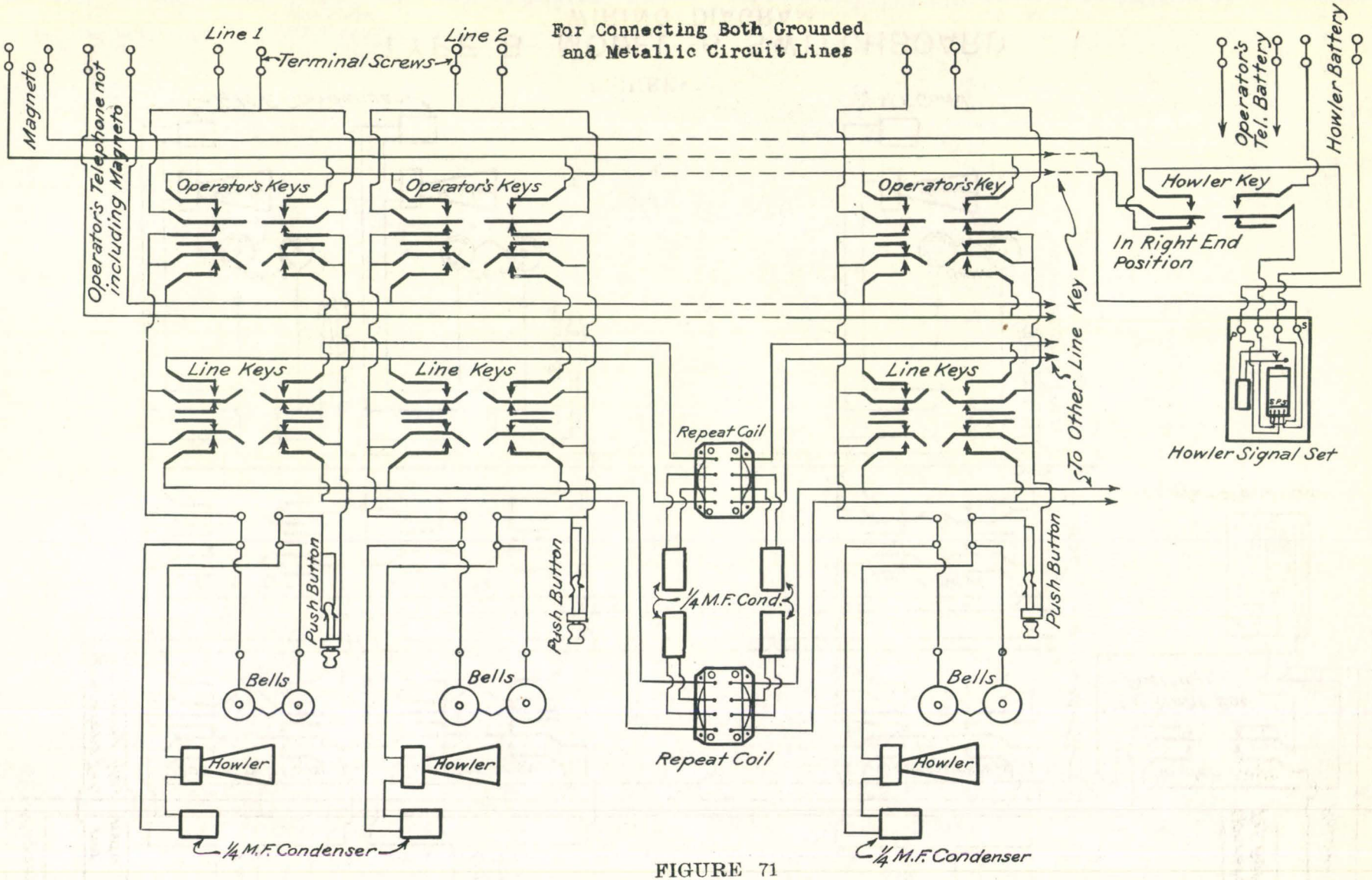


FIGURE 71

TYPE B MODEL 6 SWITCHBOARD
WIRING DIAGRAM

INSTALLATION AND OPERATING INSTRUCTIONS

for

Type E Switchboard
Either Model 5 or Model 6

If cabinet is to be attached to a wall use the four angle irons furnished for this purpose. Two are attached to the sides of the inside of the cabinet for top support and the other two furnished will be attached underneath the cabinet for bottom support.

The line wires, also the wires for operators telephone, hand generator, power ringer, etc., are to enter the cabinet, either through a hole bored on the job in one side, or up from the bottom, and connected to the binding screws on the upper side of the line terminal strip attached to the back of the cabinet.

The row of operating keys, includes one key for each line, with black handle, and one power ringer (or howler key), with red handle, located at right end of key row.

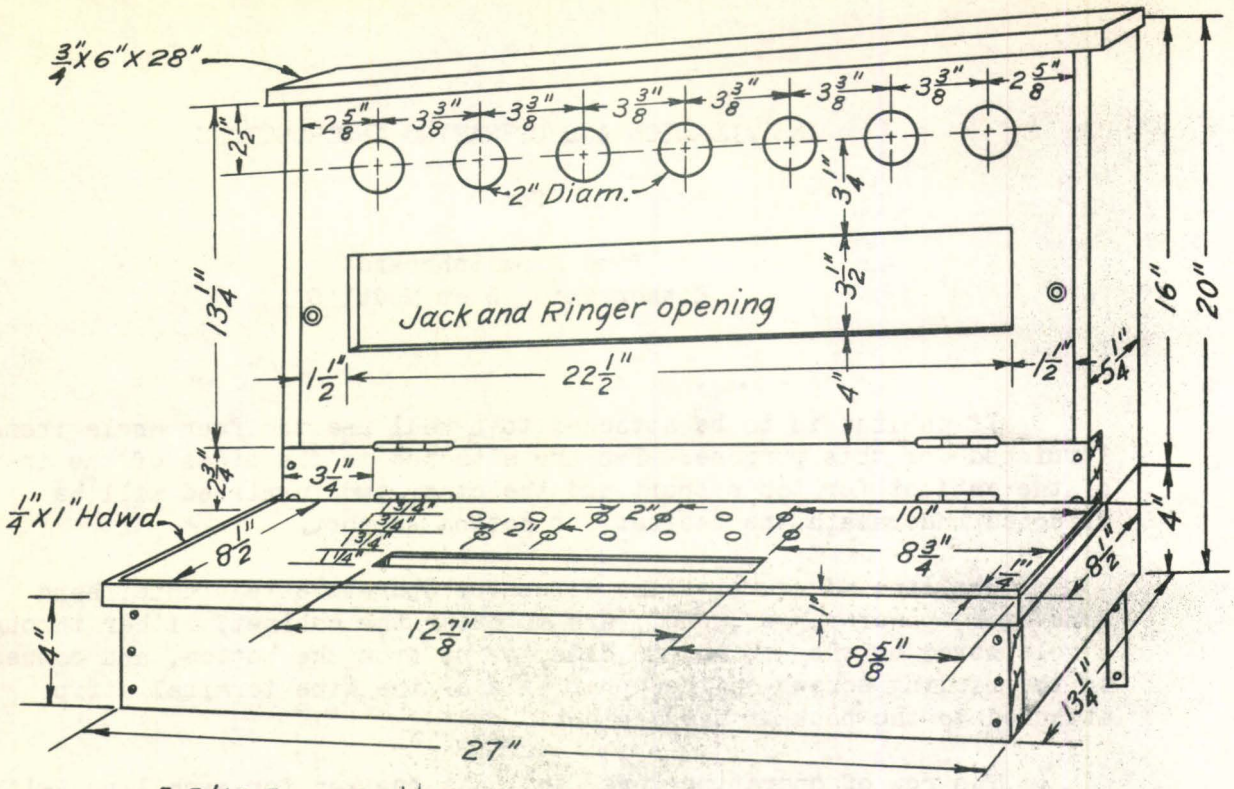
To talk on a line pull the handle of the operators key forward. This connects the line to the operators telephone talking circuit.

To ring on a line hold the handle of the operators key back (this connects the line to the ringing circuit and cuts out the operators telephone line plug and cord, jack and ringer) and either turn magneto crank, or operate the power ringer key by pushing handle back.

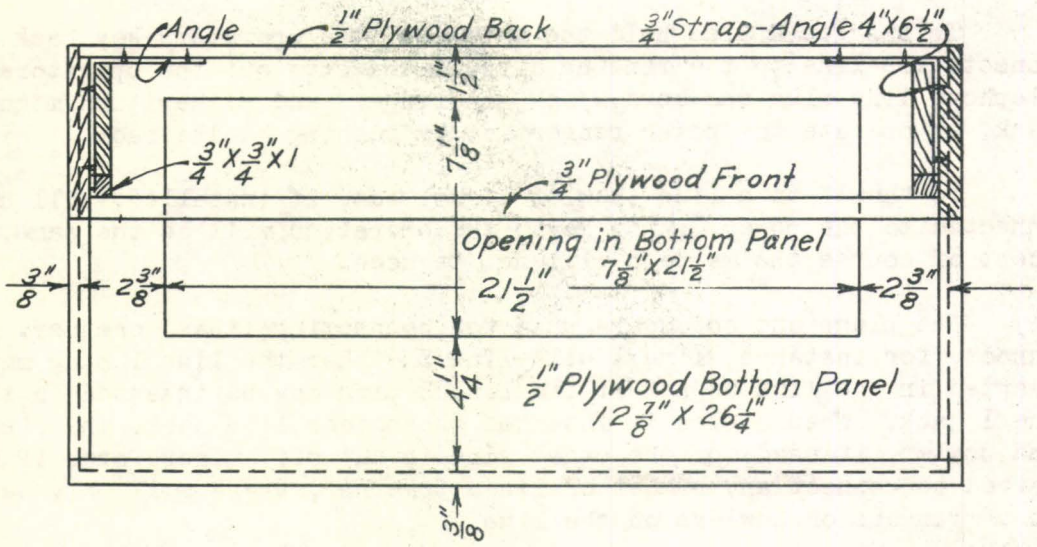
To "howl" on a line (howler signal set, if installed, will be connected to the power ringer key); the operation will be the same, except of course the magneto will not be used.

The plugs and cords are used for connecting lines together. To connect, for instance, line 1 with line 5 either the line 1 plug may be inserted in the line 5 jack or the line 5 plug may be inserted in the line 1 jack. When a plug is inserted in another line jack, the ringer (and howler, if used) of the other line is cut off. Therefore, if it is desired to connect any number of lines together, there will only be one set of ringers or howlers on the line.

FIGURE 72



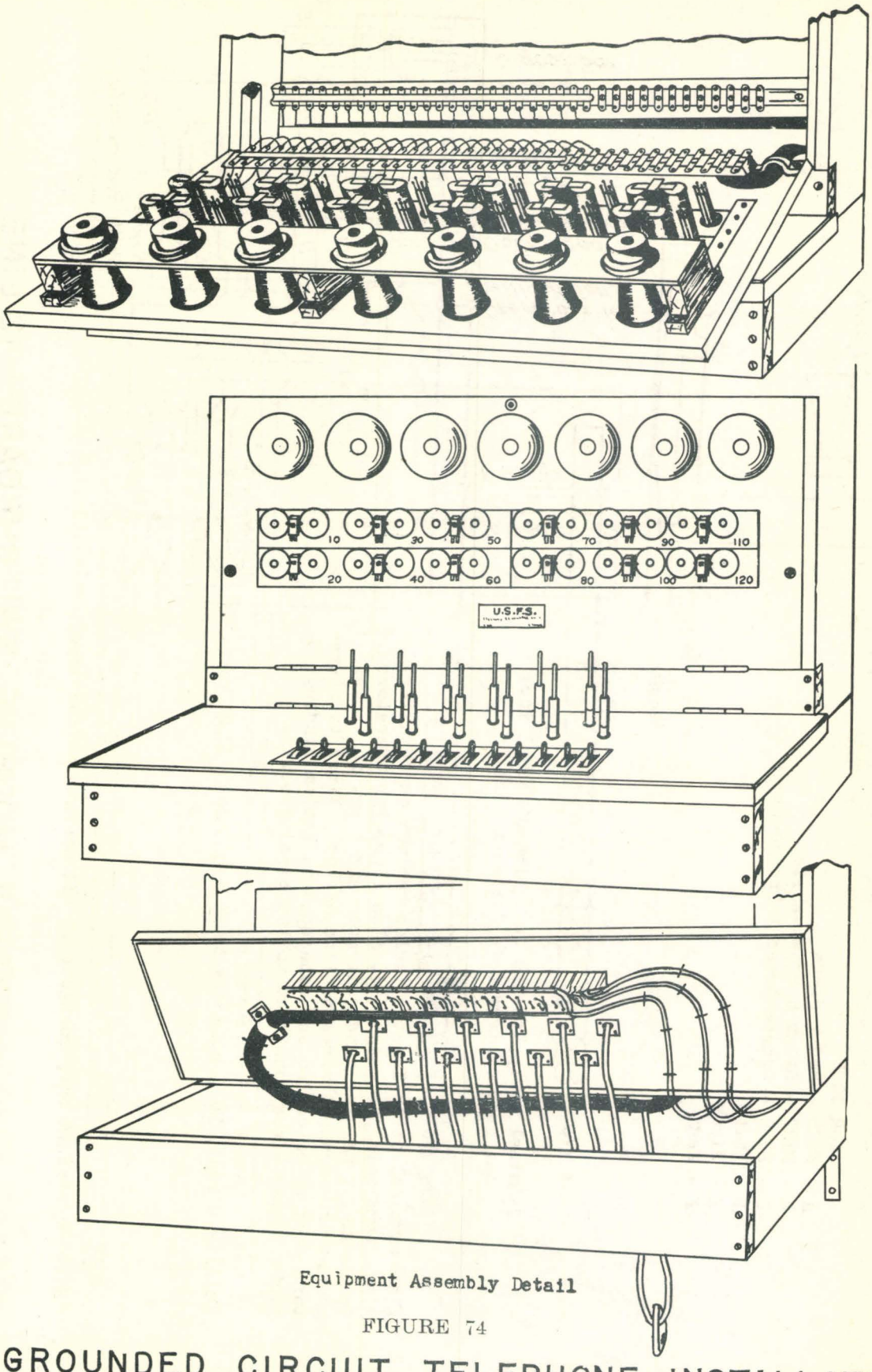
5-3/4" Top and 8½" Key Board Overhangs 3 sides by ½". For 18 line board. Cabinet 1-3/4" higher (jack and ringer opening 5¼" wide instead of 3½" wide; 4" from bottom of panel as shown).



Cabinet detail showing alternate dimensions for an 18 line switchboard.

FIGURE 73

TYPE E MODEL 6 SWITCHBOARD - 12 LINE



Equipment Assembly Detail

FIGURE 74

GROUNDED CIRCUIT TELEPHONE INSTALLATION

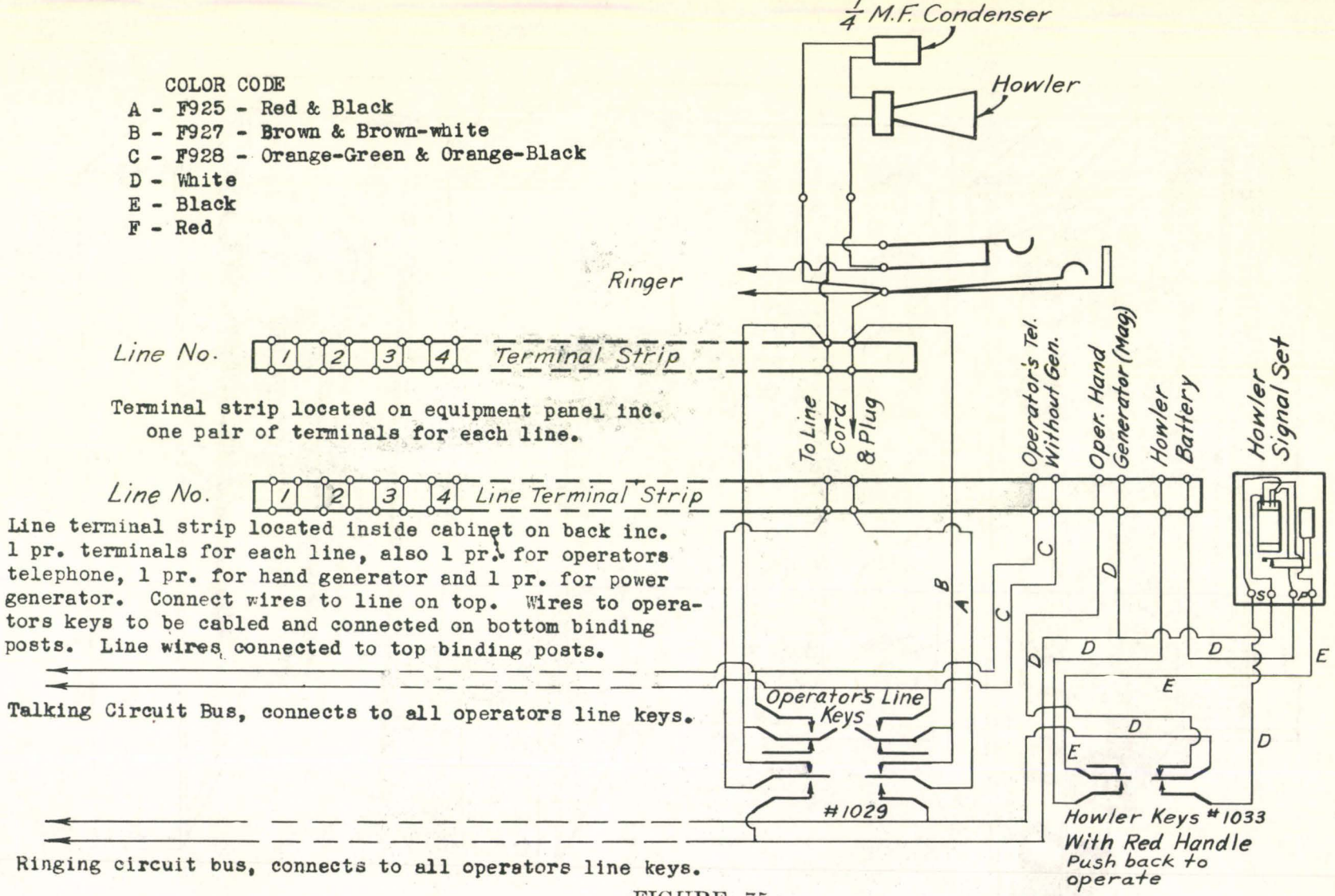
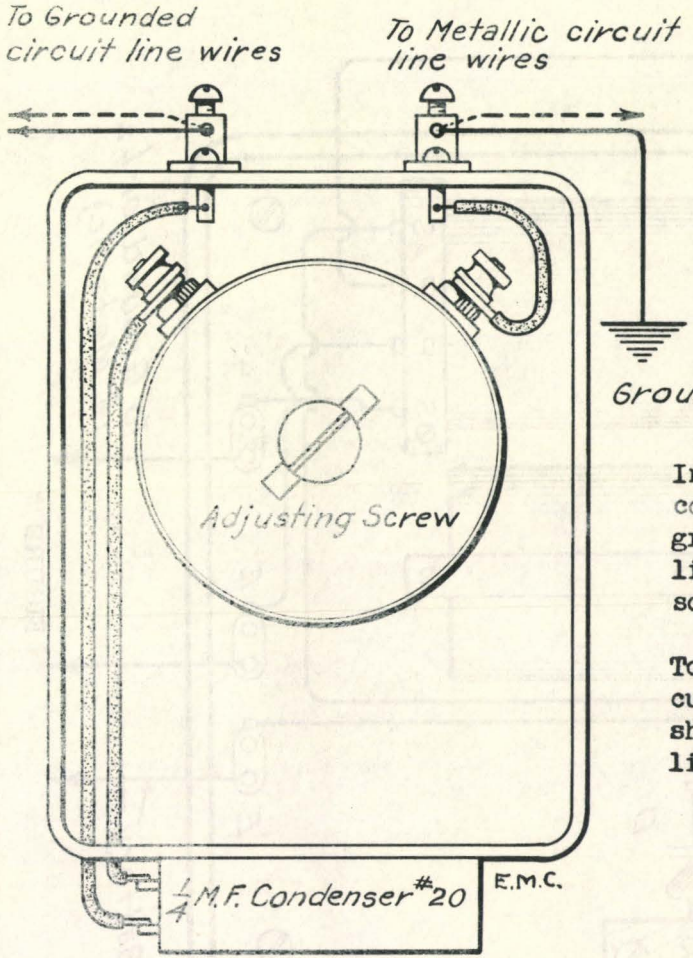


FIGURE 75

TYPE E MODEL 6 SWITCHBOARD - 12 LINE

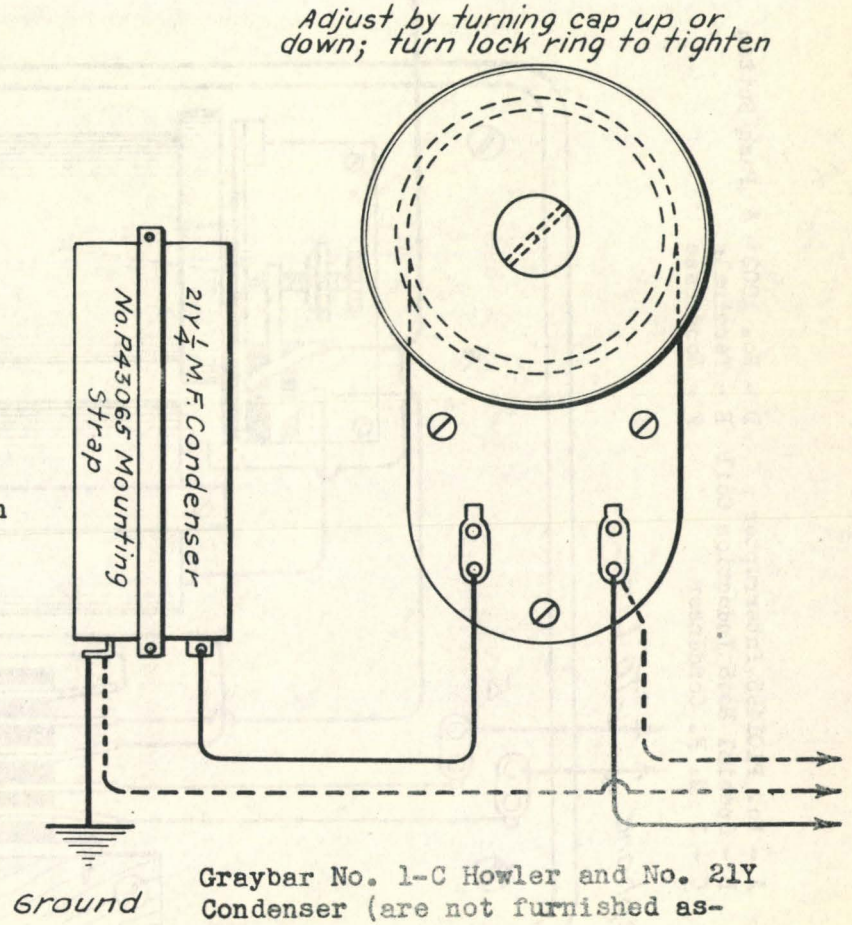
WIRING DIAGRAM



Kellogg No. 5 Howler complete (including a ¼ M.F. condenser wired as shown) mounted in a suitable wood box, on a suitable base board.

Instructions for connecting to grounded circuit line, as shown in solid lines.

To metallic circuit lines, as shown in dotted lines.



Graybar No. 1-C Howler and No. 21Y Condenser (are not furnished assembled).

FIGURE 76

TELEPHONE HOWLER CONNECTION

A - No. P101495 Interrupter
B - Special No.5 Induction Coil
C - 1 M. F. Condenser
D - No. 1002 - A Push Button
E - Terminals
F - Wood Base

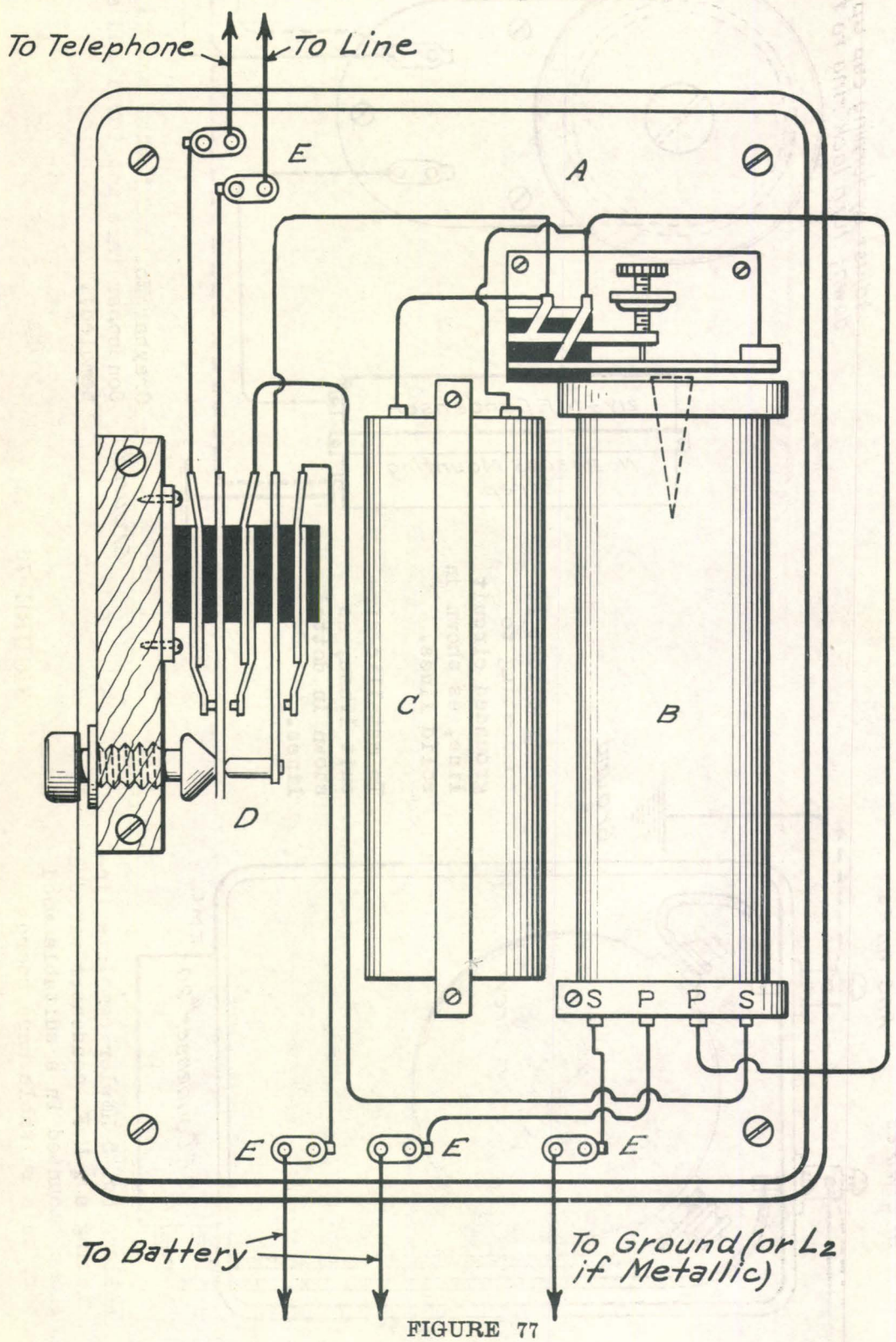


FIGURE 77

WIRING DIAGRAM FOR HOWLER SIGNAL SET

has a much greater range than the ordinary telephone, and is very effective for use on long heavily loaded lines and for "out talking" static. The telephone uses a 6 volt storage battery, or 12 dry cells, and is fitted with a plug and jack providing for the use of head phones as shown in figure 78. All telephone manufacturers have kept pace and have developed instruments to give better service.

50. Field Telephone:

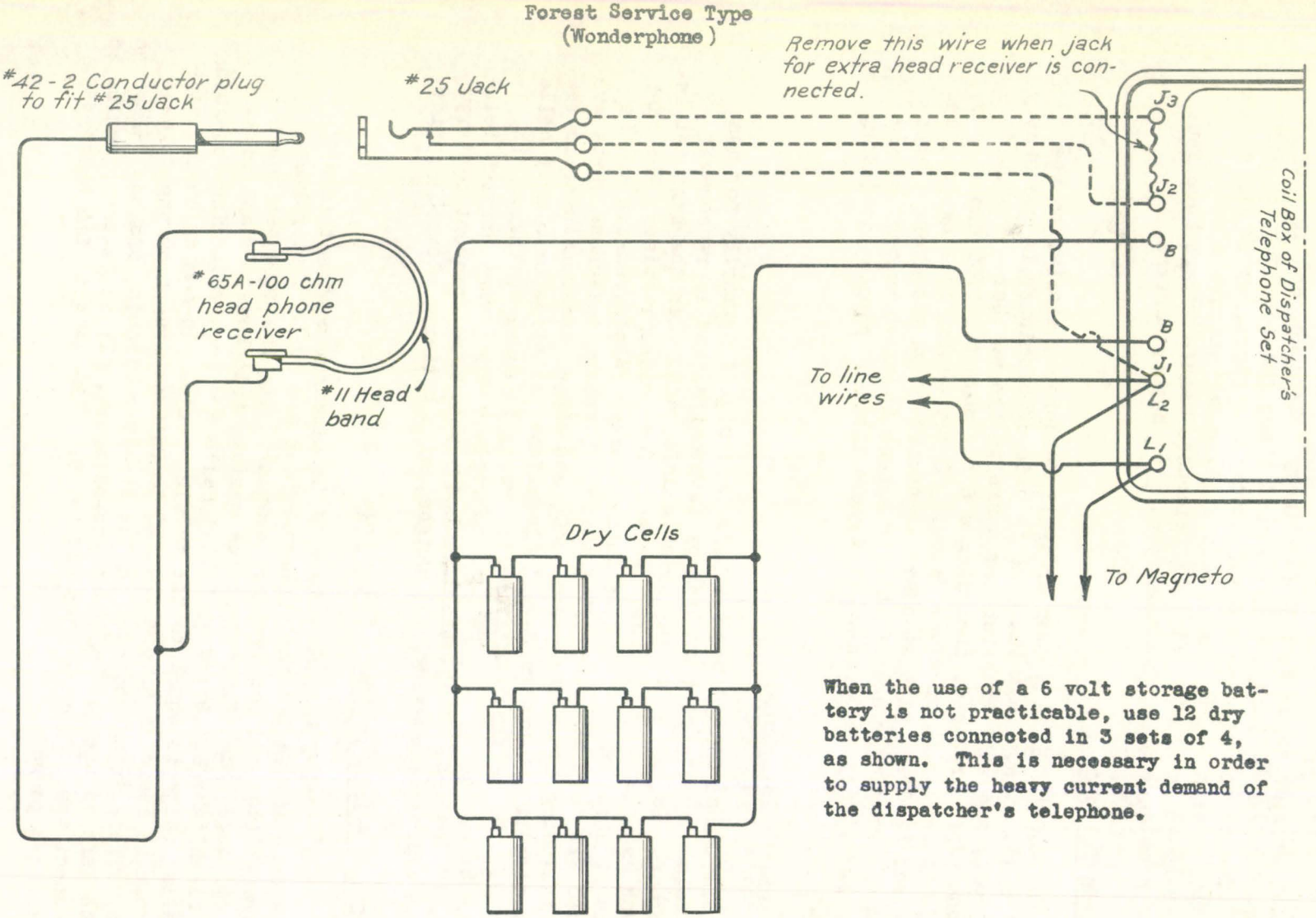
The Model A-1 is a camp or trail telephone, similar to the iron mine set except that the case is made of aluminum, is reasonably water proof, and will withstand exposure to the weather. Standard telephone parts are used, including a 6 bar magneto, 2500 ohm ringer, 1/2 M.F. condenser in receiver circuit, 3 dry cells, hook switch, and a one piece hand set with standard transmitter and receiver. The talking and ringing range of this telephone is equal to that of the average heavy duty telephone. It weighs about 30 pounds, including batteries.

51. Portable Telephone:

The Model C magneto telephone is designed primarily for use by patrolmen or others traveling by automobile, and is reasonably waterproof. It has a folding crank handle, and, when the hand set is in place and the door is shut, is ready for transportation. The case is made of hard wood, with substantial corner reinforcements and is provided with a leather carrying strap. Standard telephone parts are used, including a 5 bar magneto, 2500 ohm ringer and condenser in receiver circuit. Standard 3-cell flashlight batteries or 3 unit cells are used. The talking and signaling range is equal to that of the average telephone and can be used to replace any Forest Service telephone, if desired, except that for heavy use, more frequent battery changes will be necessary. It weighs, with battery, about 17 pounds.

52. Light Weight Portable Telephone:

The Model B telephone is a light aluminum hand set in a canvas case and is designed primarily for use by foot patrolmen. The transmitter and receiver are standard, and the hand set has a talking range equal to that of the average telephone. Standard 3-cell flashlight batteries or 3 unit cells are required. The out-going signaling range is equal to the talking range. In-coming howler signals can be heard in a room from 15 to 25 feet away from the telephone. There is a condenser in the receiver circuit, and the telephone can be left on the line without grounding it. It is better practice to disconnect the telephone when not in use. The weight with battery is about 4-1/4 pounds.



When the use of a 6 volt storage battery is not practicable, use 12 dry batteries connected in 3 sets of 4, as shown. This is necessary in order to supply the heavy current demand of the dispatcher's telephone.

FIGURE 78

DISPATCHER'S DESK TELEPHONE SET

53. Loud Sounding Signal Set:

Development of a loud sounding signal set for amplifying ring signals on Forest Service lines has been completed and the set is now available. It consists of a 2500 ohm sensitive polarized line relay, a special "loaded" 6 volt D.C. relay, a 6 volt Benjamin Industrial horn operated by either a 5 cell "Hot Shot" dry battery, six No. 6 telephone dry cells, or a 6 volt storage battery, and a battery disconnect switch wired as shown in figure 79. The relays will reproduce the code signals, long or short, as rung. The sound of the horn can be heard from one-half to one mile.

Two types of sets may be secured. One is portable and includes all equipment and battery in a substantial case suitable for transportation with outside terminals for line connections. It will weigh about seventeen pounds, including dry battery. The other type is for permanent installation at Forest Service stations. The relays, battery disconnect switch and battery are for inside mounting and the horn is for outside mounting not more than 25 feet away. Weather protection for the horn is to be provided on the job.

54. Stringing Emergency Wires:

Emergency wire lines should always be constructed in such a manner that the wire will be out of the way of travelers, stock, and game.

Two men can string the wire advantageously. One man should do the unreeling. The wire should slide through the hand as it is unreeled, and all the splices must be checked to be sure of proper connections. The second man should hang the wire on branches or limbs but should not tie it to them. The use of a forked stick will help get the wire up high enough to clear game or stock.

Sufficient slack must be provided in the wire, to allow for tree sway. If it is necessary to cross a railroad track, the wire must be placed underneath the rails. Underground highway crossings are preferable, but if aerial crossings must be made, the wire should be tied on each side, high enough to give a 20 foot clearance over the road bed. Crossing spans should not be more than 100 feet in length.

If trees or snags do not have branches suitable for supporting the wire, wooden wedges about 1/2"x1"x8" may be driven into the tree by first cutting a perpendicular gash in the tree trunk as shown in figure 80.

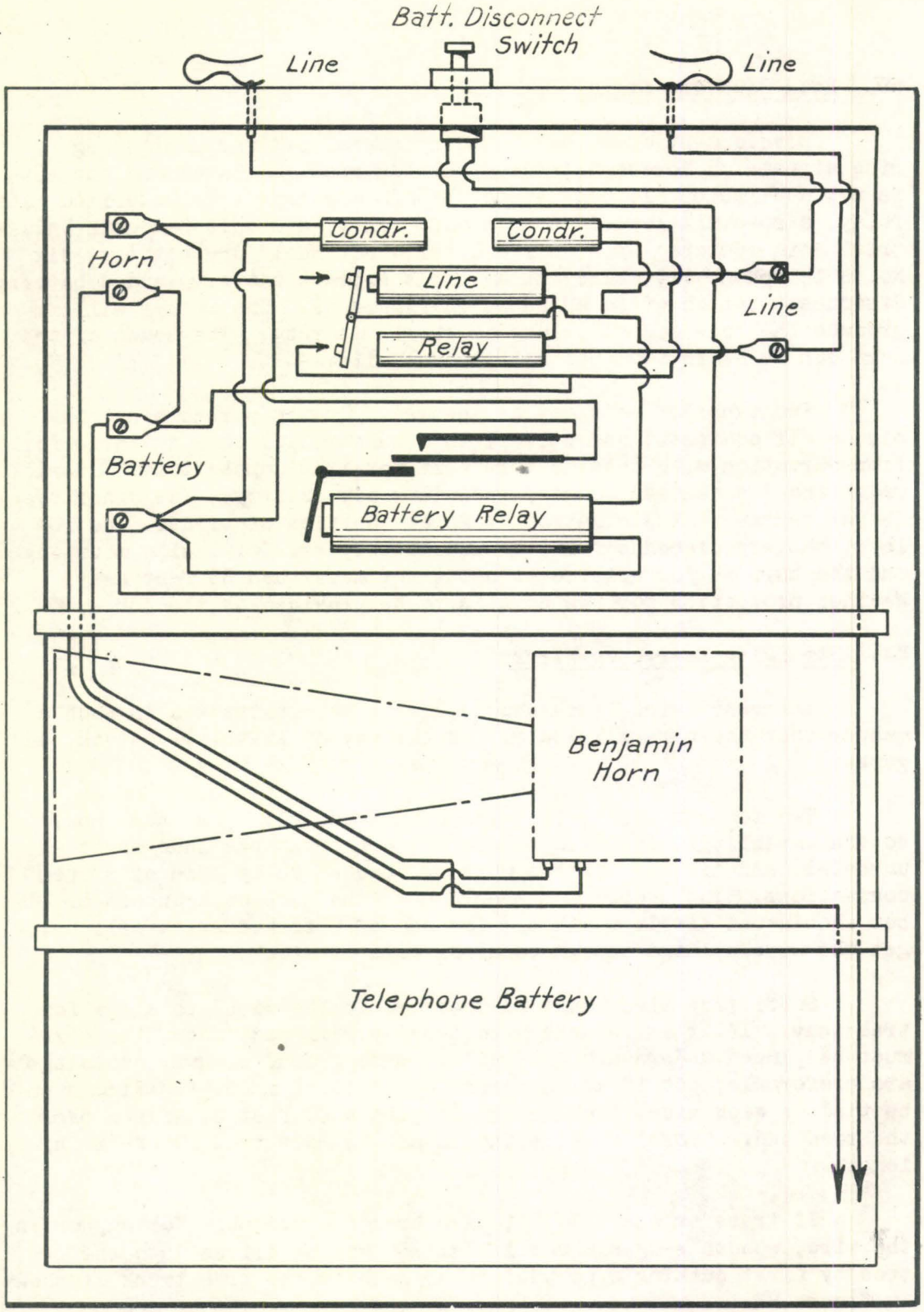
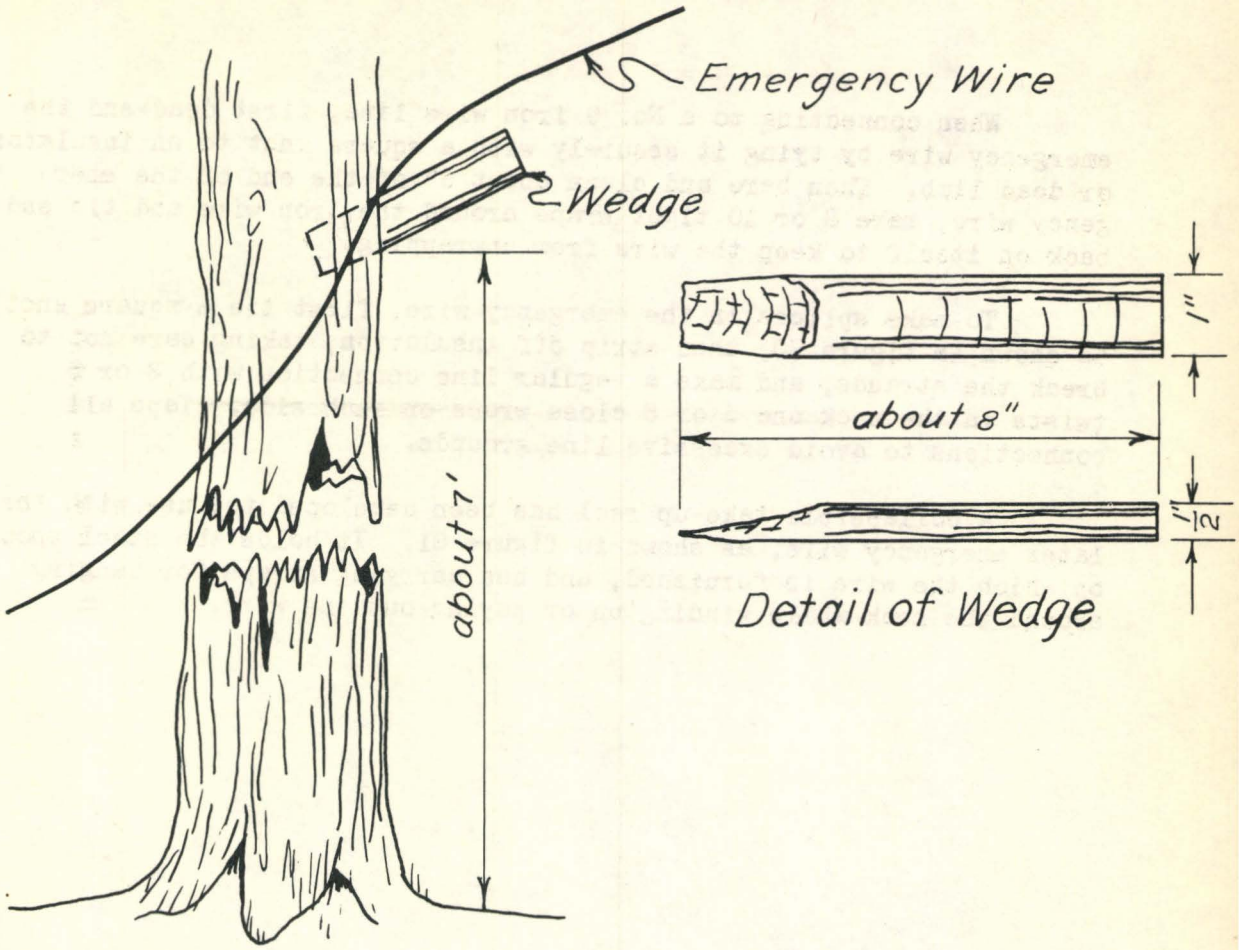


FIGURE 79

PORTABLE TYPE OF LOUD SOUNDING SIGNAL SET



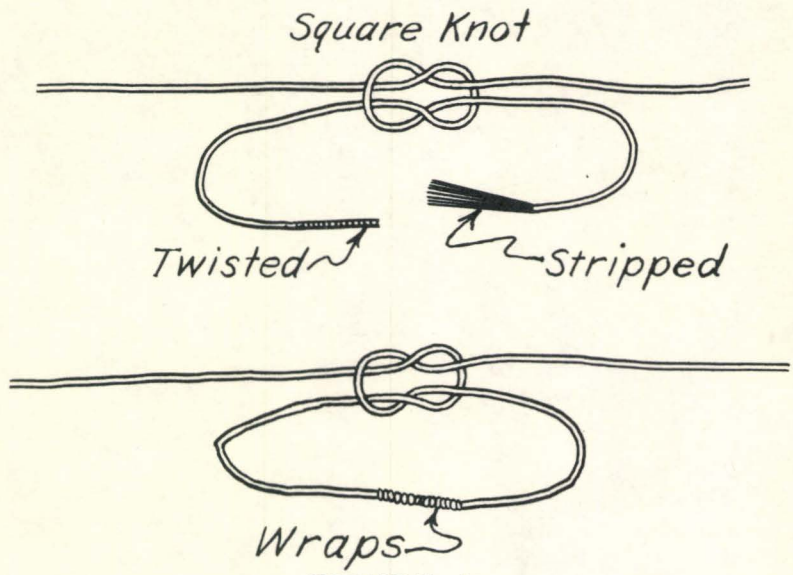


FIGURE 80

STRINGING EMERGENCY WIRES

When connecting to a No. 9 iron wire line, first dead-end the emergency wire by tying it securely with a square knot to an insulator or dead limb. Then bare and clean about 6" of the end of the emergency wire, make 8 or 10 tight wraps around the iron wire and tie end back on itself to keep the wire from unwrapping.

To make splices in the emergency wire, first tie a square knot, as shown in figure 80, then strip off insulation, taking care not to break the strands, and make a regular line connection with 2 or 3 twists in the neck and 5 or 6 close wraps on each side. Tape all connections to avoid excessive line grounds.

A collapsible take-up reel has been developed for use with the latex emergency wire, as shown in figure 81. It holds the steel spool on which the wire is furnished, and has carrying straps for hanging around the neck while winding up or paying out the wire.

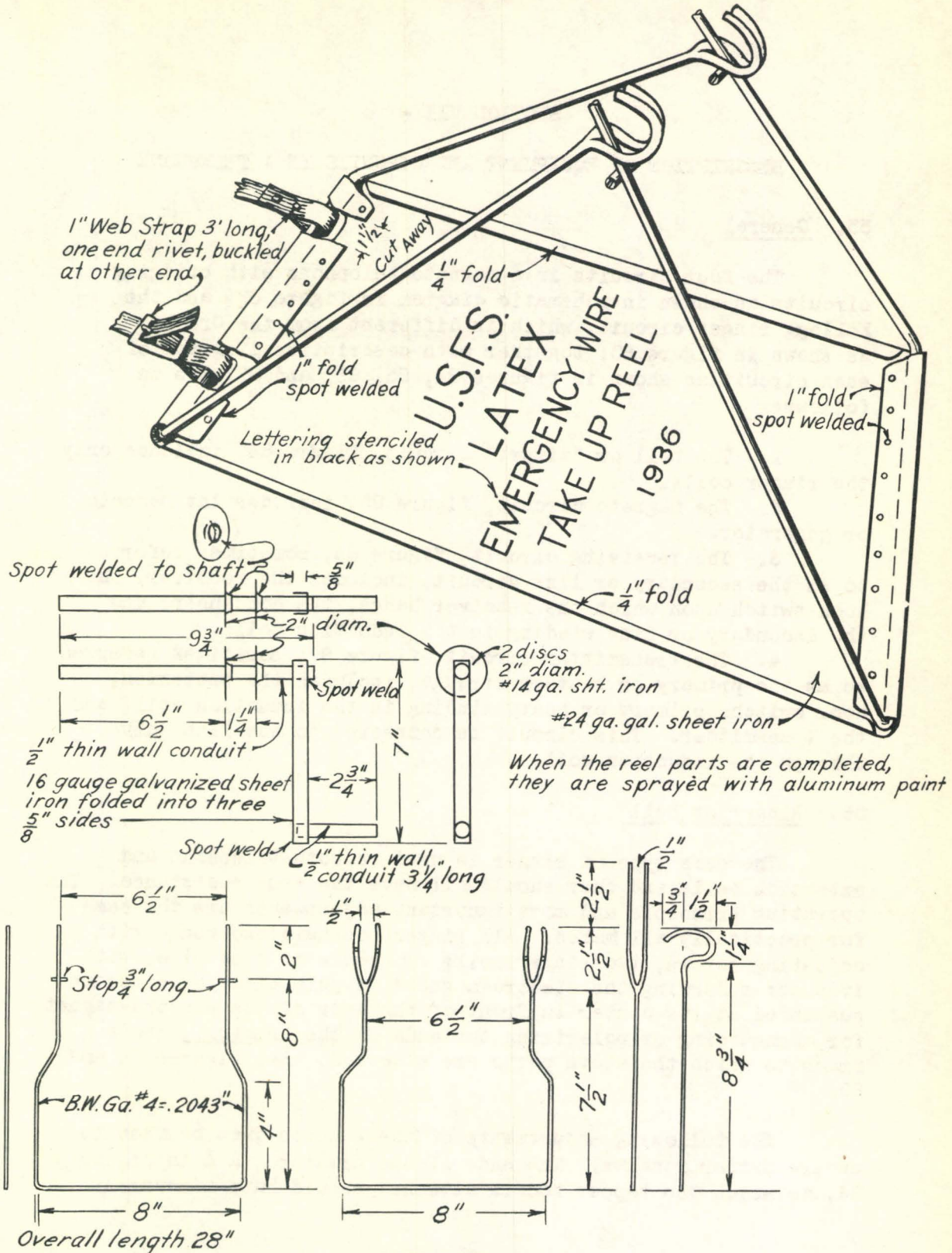


FIGURE 81

LATEX EMERGENCY WIRE TAKE-UP REEL

SECTION VII -

DESCRIPTION OF EQUIPMENT AND CIRCUITS IN A TELEPHONE

55. General

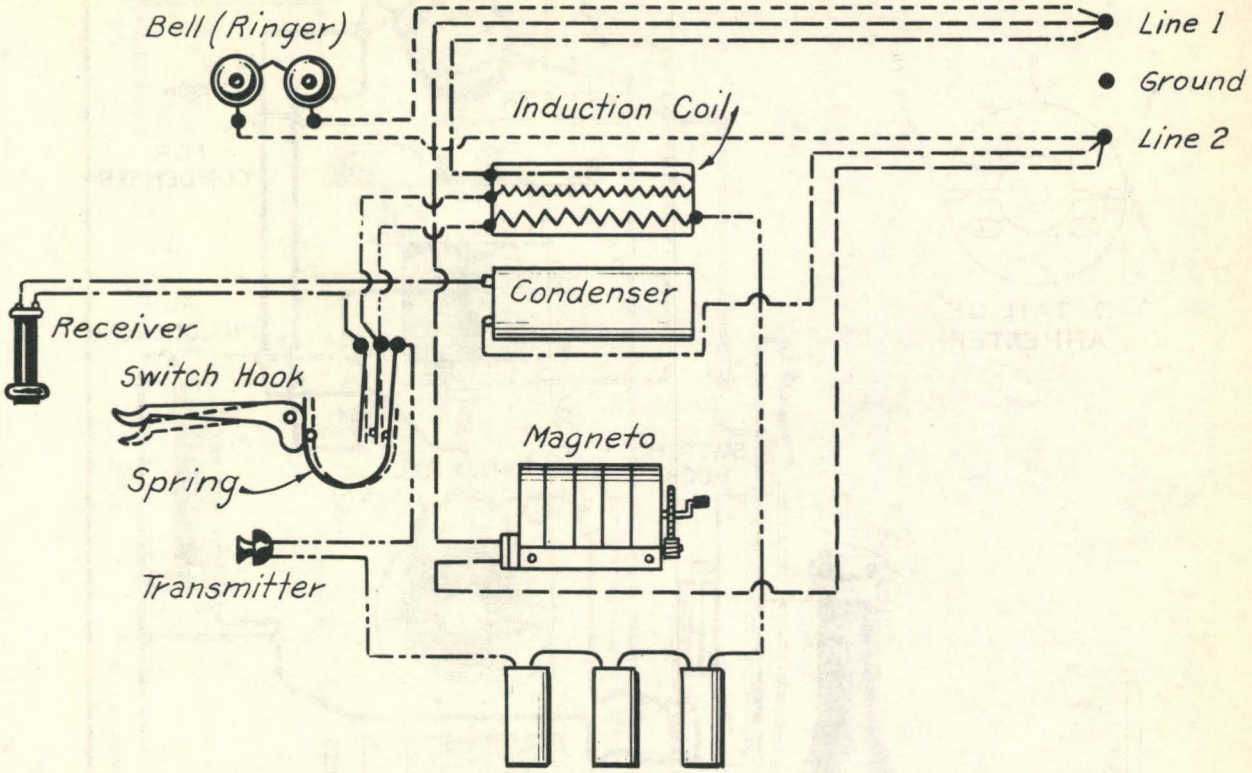
The four circuits in a magneto telephone with bridging circuits as shown in schematic diagram in figure 82, and the Kellogg ringer circuit, which is different from the Graybar as shown in figure 83; together with descriptive diagrams of each circuit as shown in figures 84, 85, 86, and 87, are as follows:

1. The bell or "ringer" circuit, figure 84, includes only the ringer coils.
2. The magneto circuit, figure 85, includes the magneto or generator.
3. The receiving circuit, figure 86, sometimes referred to as the secondary or line circuit, includes the receiver, the hook switch upon which the receiver hangs, the condenser, and the secondary or fine winding in the induction coils.
4. The transmitter circuit, figure 87, sometimes referred to as the primary or battery circuit, includes the batteries, hook switch, primary or heavy winding in the induction coil, and the transmitter. This circuit is connected to the line only through the induction coil.

56. Ringer or Bell

The same type of ringer is used in both telephone and extension bells and they should all have the same resistance. The operating principle and most important adjustments are the same for practically all makes. All ringers contain two gongs with adjusting screws, two ringer coils or spools of fine wire, with iron cores forming the electro-magnets, a pole piece or armature suspended at its center in front of the ends of the electro-magnet for magnetizing or polarizing the ends of the armature, and a frame to which the above parts are attached. See figures 88 and 89.

The following adjustments of these parts must be made to secure proper results. The ends of the armature, A A in figure 84, to which the tapper rod is attached should have a movement



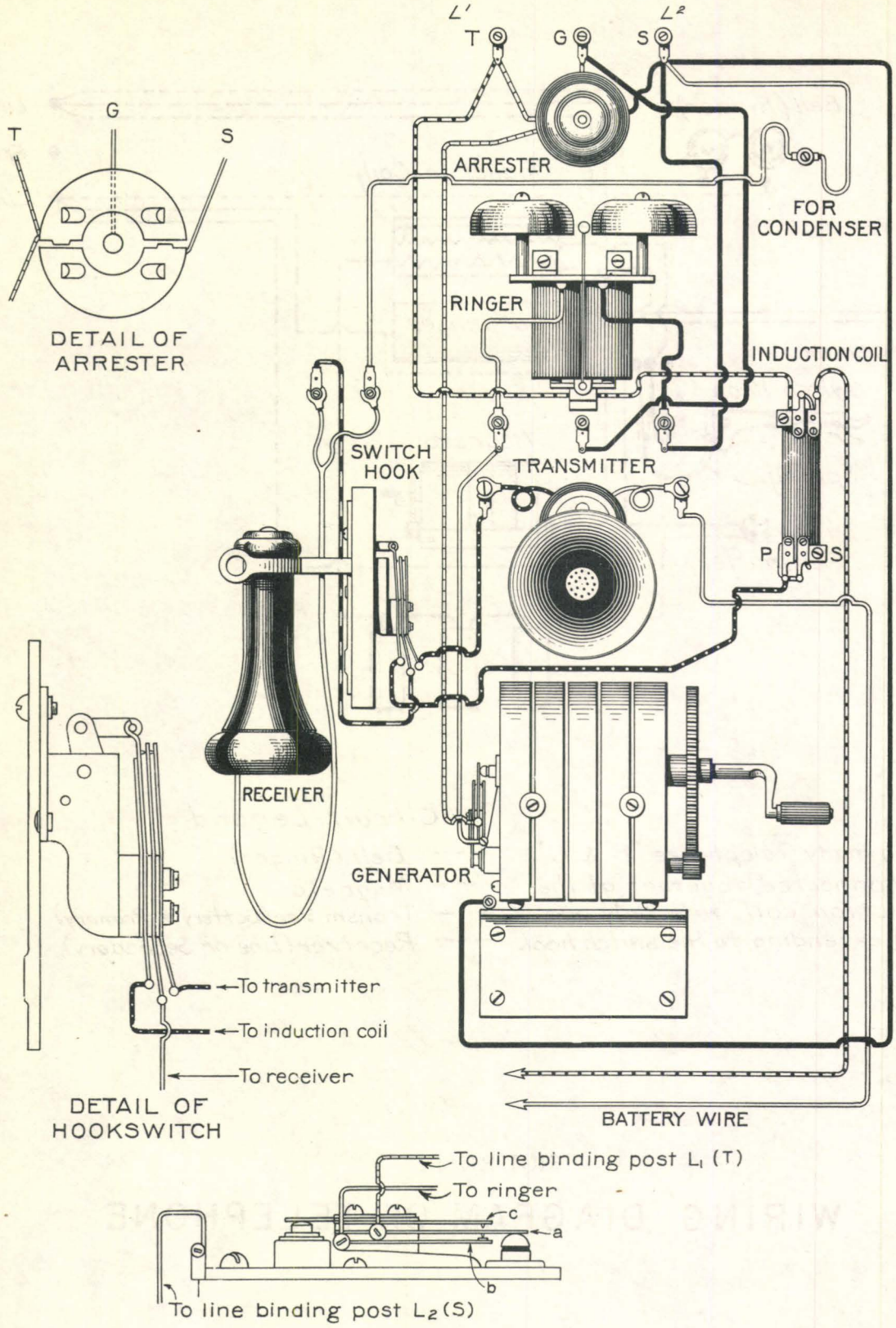
In many Telephones "B" & "C" are connected together at the induction coil, with only one wire extending to the switch hook.

Circuit Legend

----- Bell (Ringer)
- — — Magneto
- · — Transmitter (Battery or Primary)
— · — Receiver (Line or Secondary)

FIGURE 82

WIRING DIAGRAM OF TELEPHONE



DETAIL OF ARRESTER

DETAIL OF HOOKSWITCH

DETAIL OF GENERATOR TERMINALS

FIG. 83

WIRING DIAGRAM OF KELLOGG TELEPHONE

As the ringing currents alternate in direction, the magnetism in the ringer coils is reversed, alternately pulling first one end of the armature and then the other.

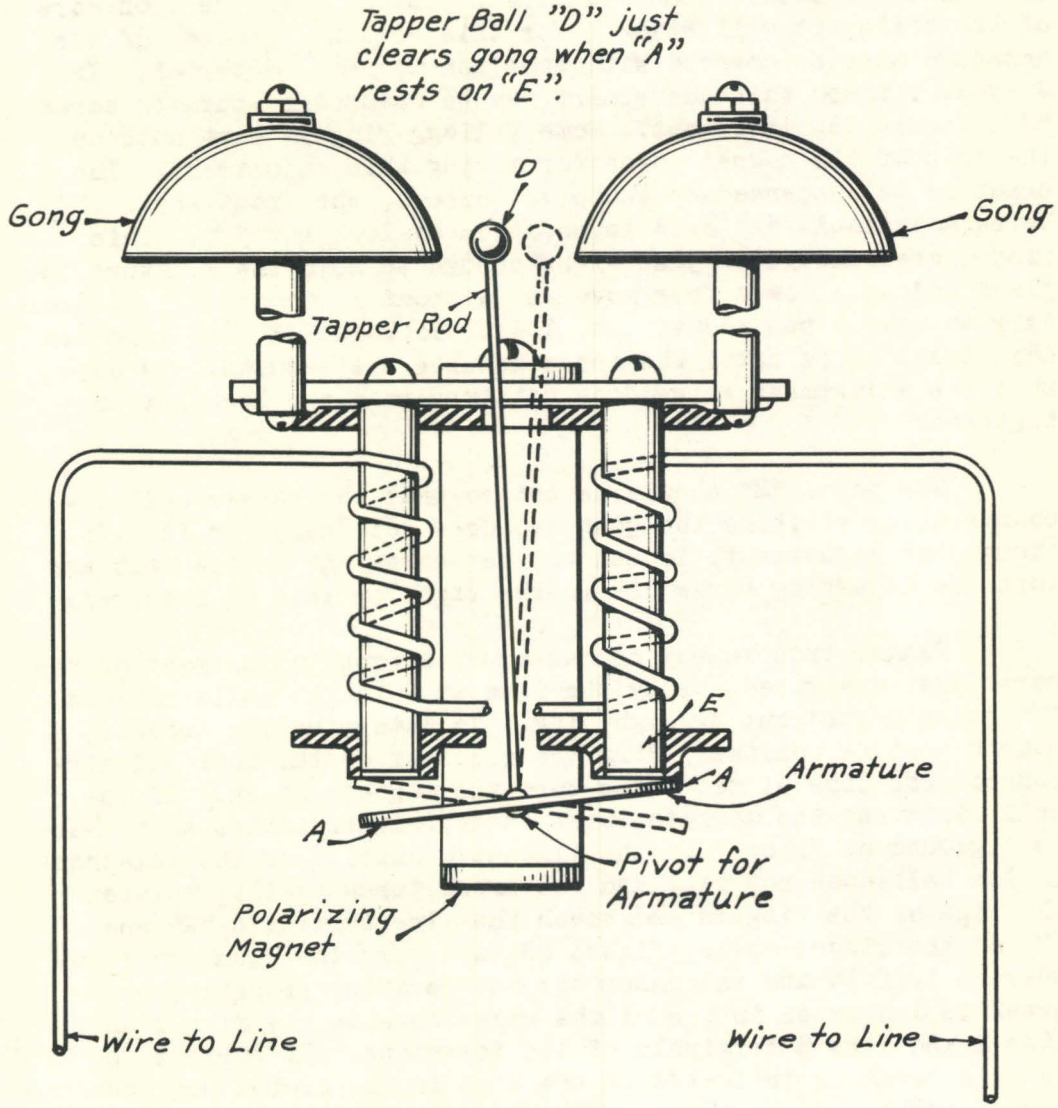


FIGURE 84

RINGER

of about 3/32 inch back and forth in front of the ends of the electro-magnets. A little more movement is necessary for short lines, and a little less for long, heavily loaded lines. If the iron in the armature comes in direct contact with the iron core of the coils, it will stick. For this reason, the ends of the armature must be covered with some non-magnetic material. In Graybar ringers this adjustment may be changed by turning screw "C", figure 88, in or out. Some Kellogg ringers have nuts on the ends of the magnet cores for making this adjustment. The armature is suspended by two pivot screws, the front screw "N" being adjustable and held in position by lock nut "E". This front screw should be just tight enough to hold the armature in place and to allow a free movement without lost motion. If necessary to make a new adjustment, loosen lock nut "E" and turn the adjustment screw until the above results are secured. Be sure that the adjustment screw does not turn when the lock nut is tightened.

The gongs "M" should be set so that the tapper ball rebounds after striking the gong and does not "hang" to it. To change the adjustment, loosen the set screw "A" on the back and turn the adjusting screw "B" to the right or left as required.

Ringer trouble may be caused by a wrong adjustment of the parts just described, or by the fine wire in the coils "F" and "F" being burned out by lightning. To determine the trouble, make a test as follows: Hang the receiver on the hook and disconnect the line wires. Then turn the magneto crank. If the bell rings and the magneto turns easily, it indicates that there is a ground or "short" on the line wire outside of the telephone. If the bell does not ring and the crank turns easily, moisten the tips of the fingers and touch the line terminals "X" and "Y" on the ringer coils, figure 88, and turn the crank. If no current is felt and the generator is operating properly, a break is indicated in one of the wires between the ringer and line 1 and line 2 terminals of the telephone. If current is felt, a break is indicated in the wire in one or both of the ringer coils.

In the Kellogg telephone, one ringer coil wire is connected directly to the line 2 binding post, and the other one

is connected to the other line through the back contact on the magneto contact assembly, as shown in figure 83. When the magneto crank is turned, this contact is opened, opening the ringer circuit. To test the ringer coils as previously described, it will be necessary to make a short circuit between this contact spring and the one next to it while turning the crank. This may be done by inserting a knife blade or small screw driver between the two springs.

57. The Magneto or Generator

This is merely a type of a dynamo having permanent magnets in horse shoe shape, and an armature consisting of a single coil wound on a round piece of iron for a shaft. See figures 85 and 90. The action of turning the crank causes the armature to revolve between the ends of the magnets, producing an electric current alternating in direction in the armature coil. One end of this coil is connected to the metal part or frame of the magneto. The other end is connected to an insulated conductor through the center of the armature shaft, which is hollow, to the left end, "F" in figure 90, and makes contact with an outside spring "E". This is not connected directly to the line wire, but when the crank is turned, the crank shaft is forced to the left by a coil spring in the shaft, pushing the upper end "C" of the spring against the line contact. This completes the ringing circuit, as the ground wire is connected to the other end of the armature coil through the frame. The sliding action of the crank shaft connects the armature coil to the line when the crank is turned and breaks the connection when the turning motion is stopped, thus keeping the generator disconnected from the line when it is not in use. This is necessary because the resistance of the armature coil is low enough to cause a ground on the line if it is left connected at all times. In the Kellogg telephone, figure 83, the action of the magneto spring contacts is as just described for the Graybar telephone, except that the ringer connection which is made between contacts "A" and "B" is broken when the generator crank is turned, as the action of turning the crank causes the crank shaft to slide forward to the left.

Make magneto tests as follows: Be sure the receiver is on the hook and then disconnect line wires L_1 and L_2. Place the fingers across these terminals as shown in figure 91 and turn the crank. If a very stinging sensation or shock is felt, this indicates that

Diagram illustrating the principle of the operation of the magneto. The strength of the ringing current is increased to some extent by turning the crank more rapidly. The current thus generated alternates or reverses in direction once for each revolution of the armature (from 16 to 20 times a second).

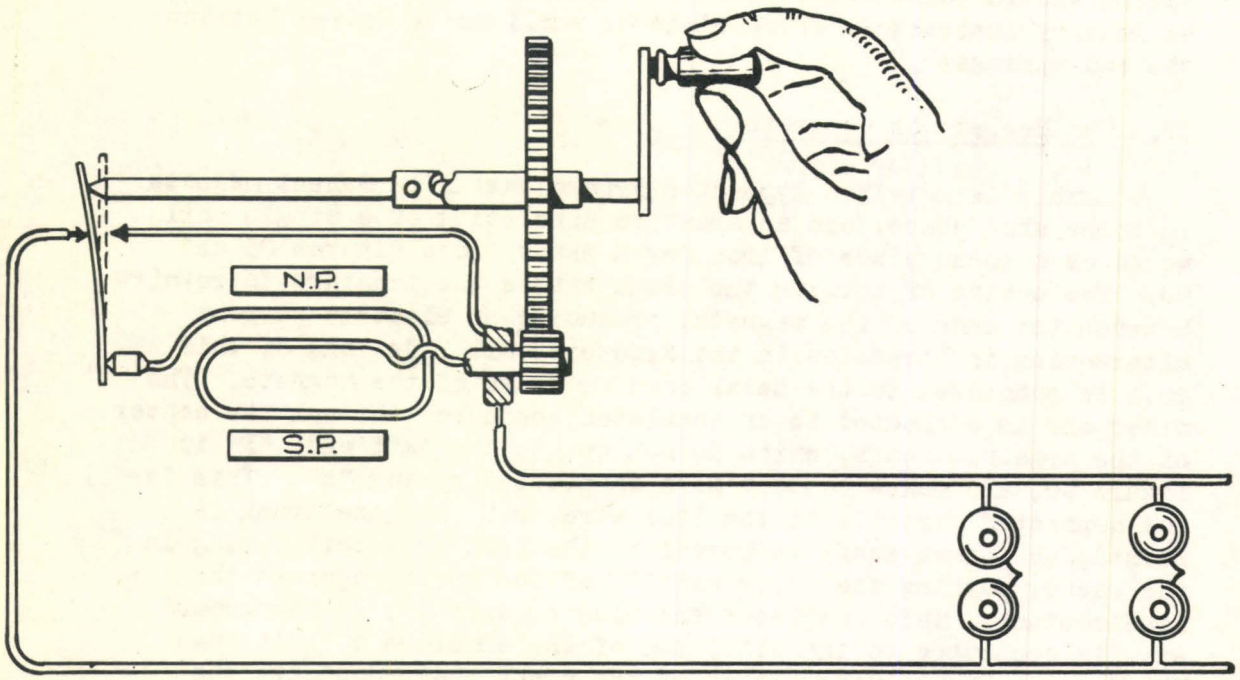


FIGURE 85

MAGNETO

the generator is operating and is probably all right. If there is no stinging sensation or shock felt, there is trouble in the wiring in the telephone or in the generator. To test the wiring in the telephone, remove the generator wires from terminals "x" and "y" figure 90, for Graybar magneto, or "a" and "b", figure 83, detail of generator assembly, for other telephones. Put the fingers on these terminals and turn the crank. If a stinging sensation is felt, the trouble is in the wiring in the telephone; if not, it is in the magneto and it will be found open or short circuited. If the crank turns hard, the trouble in all probability is a short circuit in the rubber bushings separating the spring contacts. This is usually caused by lightning but may be caused by too much oil. In either case, there will probably be an odor of burning rubber. In order to be sure that this is the trouble, it will be necessary to take the generator out of the telephone and remove the entire spring contact assembly by taking out the two end screws. Do this carefully, for if the trouble is not here, the springs and insulating strips must be put back exactly as they were. Then turn the crank and if it still turns hard, the trouble is in the armature. It may be either a "short", in which event a new armature should be secured, or mechanical trouble at the bearings, which usually can be corrected with a few drops of typewriter oil. If the crank turns easily, the trouble is in the spring contact assembly. It is advisable to have an extra complete magneto spring contact assembly on hand. If a new assembly cannot be secured, it may be possible to make temporary repairs on the job by taking the old assembly apart, locating the defective insulating strip and then scraping off the carbonization carefully. A thin piece of cardboard may be substituted for the defective strip in an emergency. Replace the parts, being sure to wipe each piece clean and put them back exactly as they were.

It sometimes happens that the permanent magnets on the generator become weak after long usage. This will be indicated by a reduction in the amount of current the generator gives when the crank is turned rapidly. If this is the case, it will be advisable to replace it with a new set. Sometimes the generator is weak because someone has taken it apart and replaced a magnet incorrectly. Each magnet has a punch mark on it, and these marks should all face in the same direction. If one magnet is reversed, the strength of the generator will be greatly reduced. The magneto should be oiled occasionally by putting a drop or two of typewriter oil in each oil hole.

58. Receiver

The function of the receiver has been described in part under "Transmitter". There is only about a sixty-fourth of an inch clearance between the diaphragm and the ends of the receiver magnet cores.

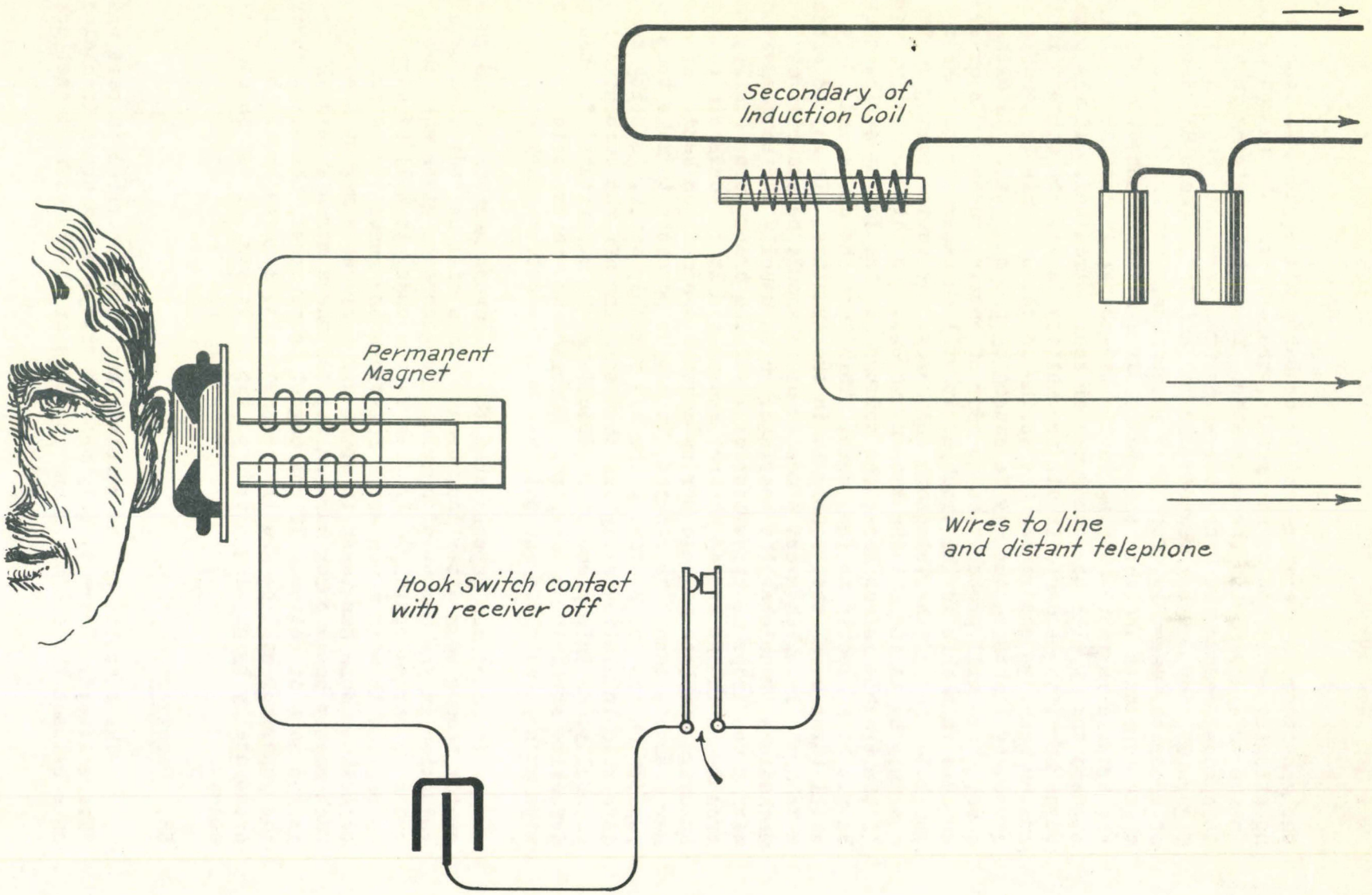


FIGURE 86

RECEIVING

See figure 86. It is important, therefore, that any dust or filings which may be inside the receiver be cleaned out, and if the diaphragm is dented, it should be either reversed or replaced with a new one. If the receiver has been dropped, the magnets may be jarred out of place. If the fine wire on the receiver magnets has been burned out by lightning, the receiver should be replaced with a new one. Convenient methods of testing a receiver or receiver cord are shown in figure 92.

59. Transmitter

Following is a brief description of the action of the transmitter. Vibrations in the transmitter diaphragm, figure 87, set up by the voice sound waves, compress the pulverized carbon in the small cup called the microphone, with varying degrees of intensity. This changes the resistance of the transmitter circuit, resulting in electric current variations, corresponding to the sound wave variations.

The current variations set up by the transmitter pass through the primary windings of the induction coil which induces a similar varying current with a greater pressure or higher voltage in the secondary winding. This current passes through the line wire to the receiver at the receiving telephone. These variations of electric current produce changes in the magnetic strength of the receiver magnets. This alternately attracts and repels the receiver diaphragm causing it to have a vibration similar to that imparted to the transmitter diaphragm by the sound waves and reproduces the sound.

There are no adjustments to make, but it may be tested as shown in figure 93. First be sure the batteries in the telephone are good and connected correctly as shown in figure 61. Then disconnect the line wires and put a jumper between L_1 and L_2 binding posts, tap the transmitter and blow in it with receiver to ear as shown in figure 93. If you do not hear anything, it is most likely that the fine carbon in the microphone, figure 87, is packed. This can usually be remedied by moving the transmitter arm up and down rapidly. If the switch hook contacts have been bent, or are dirty, see the following paragraph.

60. Switch Hook

The switch hook is in both receiver and transmitter circuits. See figure 82. Some makes of telephones have four springs, two for

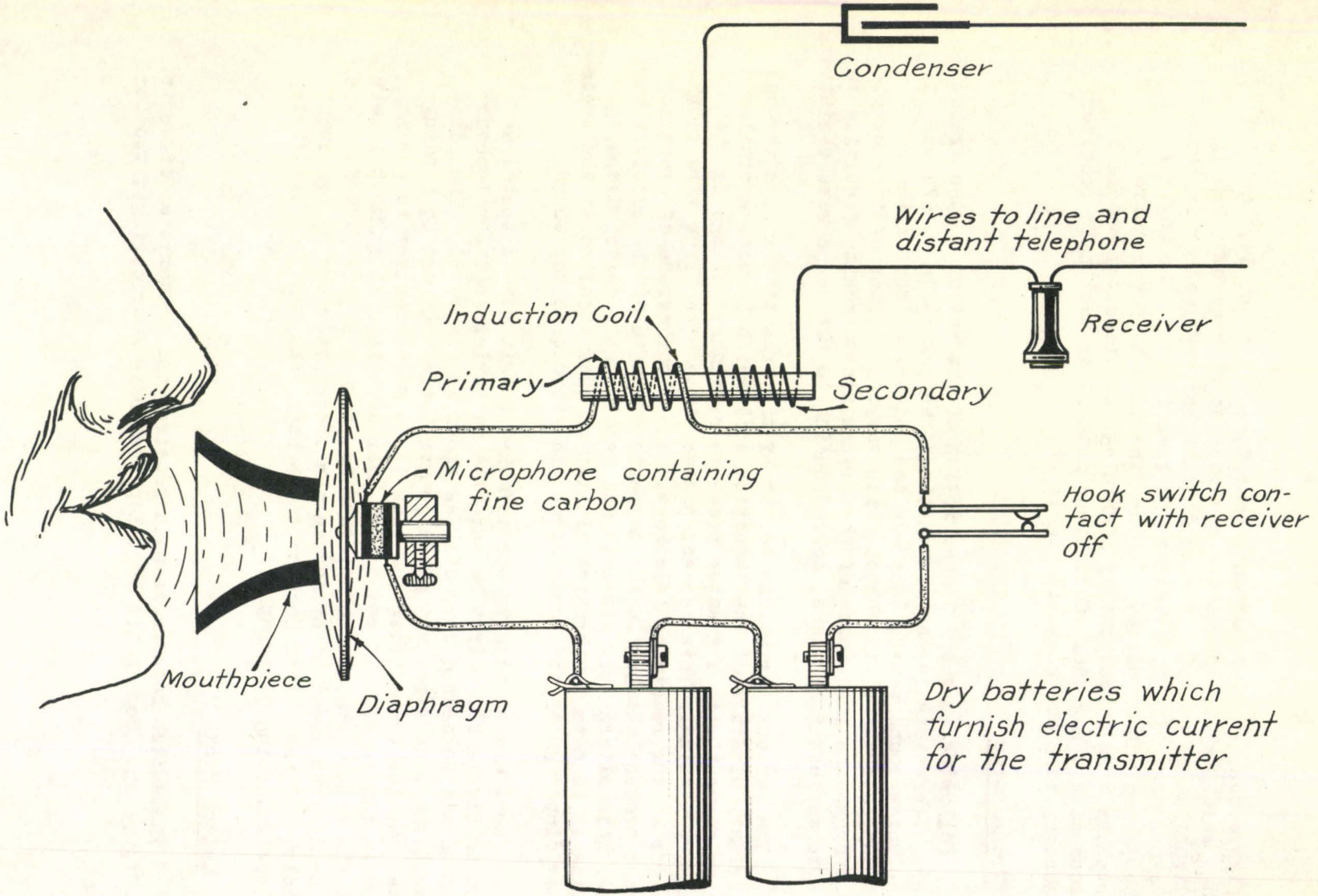


FIGURE 87

TALKING

each of the transmitter and receiver circuits, and the action is similar in either case. When the receiver is off the hook, all springs make contact and when it is on the hook, all should be open. If they do not clear each other when the receiver is on the hook, line noises can be heard in the receiver and the battery will run down rapidly. Bend the springs a little, if necessary, to secure the proper clearance. The insulation between these springs may be injured by oil or lightning and will cause the same effects. In this event, the entire switch hook assembly should be replaced with a new one.

61. Induction Coil

This is also in both receiver and transmitter circuits. Its function is to change the low voltage battery current in the transmitter circuit to a high voltage current which goes out on the line. This change is necessary because the voltage or pressure furnished by the three dry batteries in the transmitter circuit is too low to overcome the resistance of the line. While the induction coil is in the transmitter circuit, it seldom gets out of order. If it does, the coil should be replaced. See figures 82, 86, and 87.

62. Condenser

The condenser is made of strips of tin foil separated by thin sheets of paraffined paper. It has a high resistance to the low frequency ringing current and practically no resistance to the high frequency talking current. In the event there is no condenser in the receiver circuit when the receiver of the telephone is taken off the hook, a circuit would be connected to the line by means of the hook switch, which would include only the receiver and the secondary winding of the induction coil. See figure 92. As their combined resistance is only about 150 ohms, which is very much lower than the resistance of the ringer coils, it would amount to a bad ground on the line and the other bells on the line would not ring. This is shown graphically in figure 94.

Condenser trouble seldom occurs. However, lightning may burn it out or short-circuit it. If burned out, there will be no interference with the ringing, but neither talking nor receiving can be accomplished. If a condenser is thought to be open, a wire across the two condenser terminals will permit voice transmission. If a condenser is short-circuited, no difference will be noticed in talking or receiving, but the generator crank will turn very hard and there will be a ground on the line, as previously stated, if the receiver is left off the hook switch. In either event, the defective condenser should be replaced with a new one.

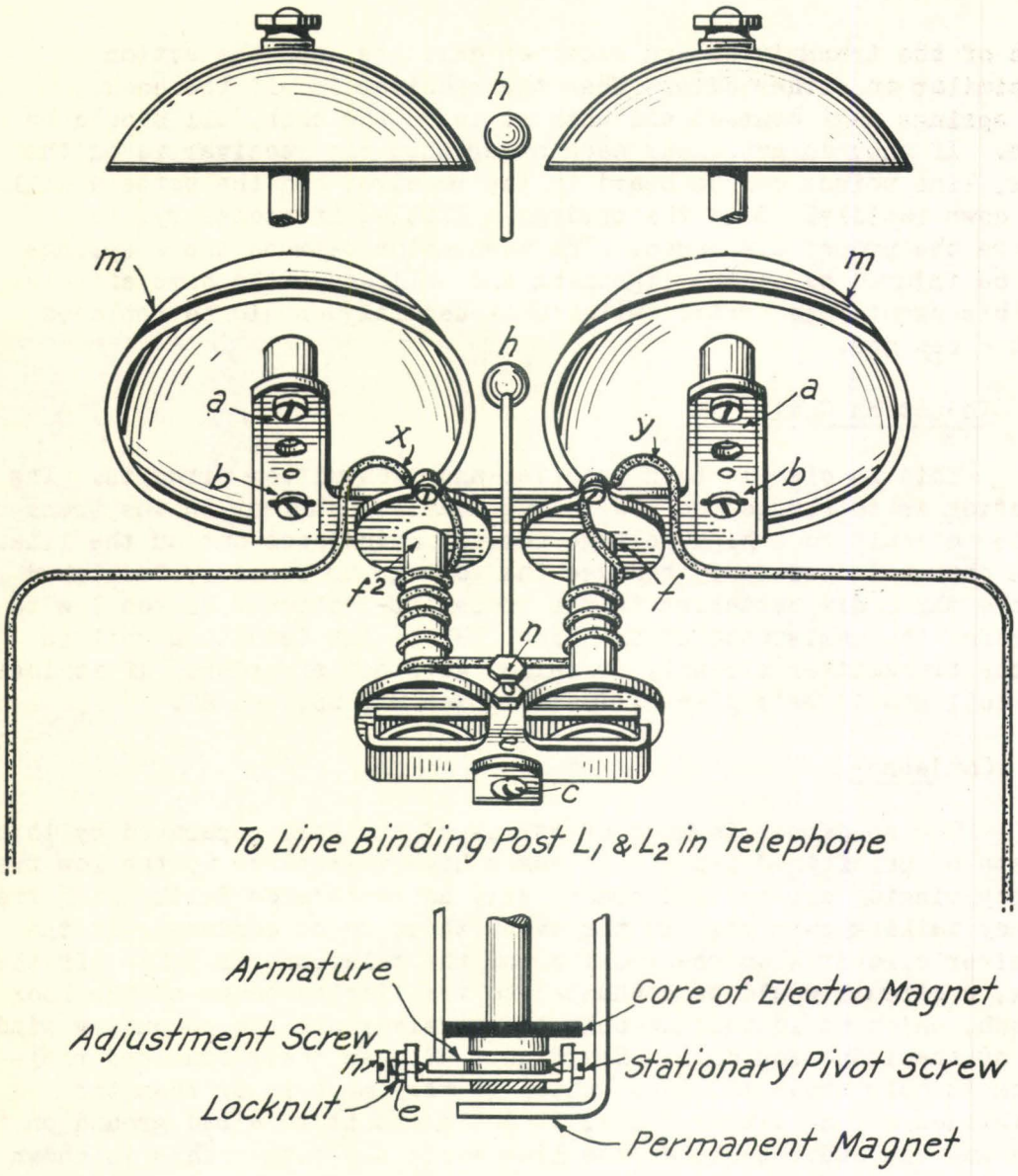


FIGURE 88

GRAYBAR TELEPHONE RINGER

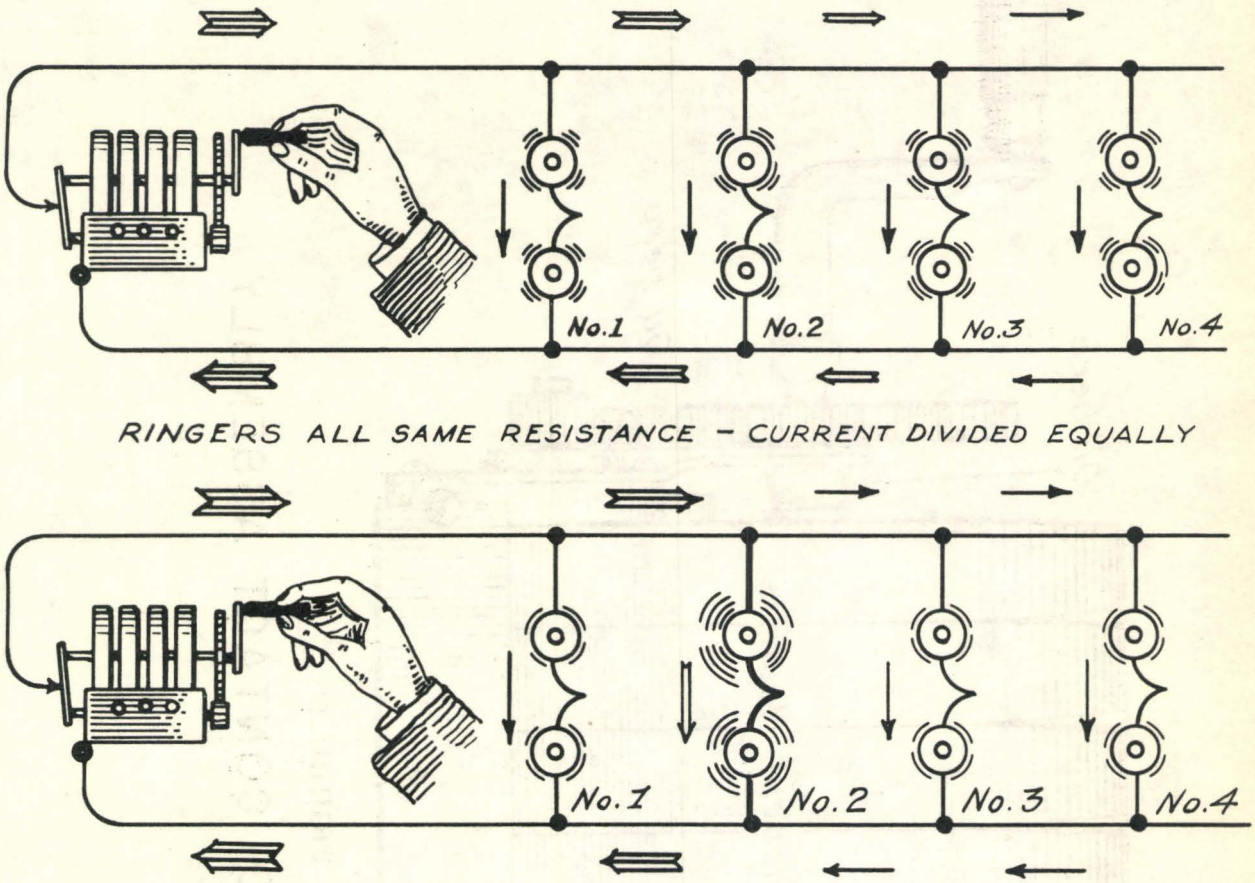


FIGURE 89

RINGER RESISTANCE

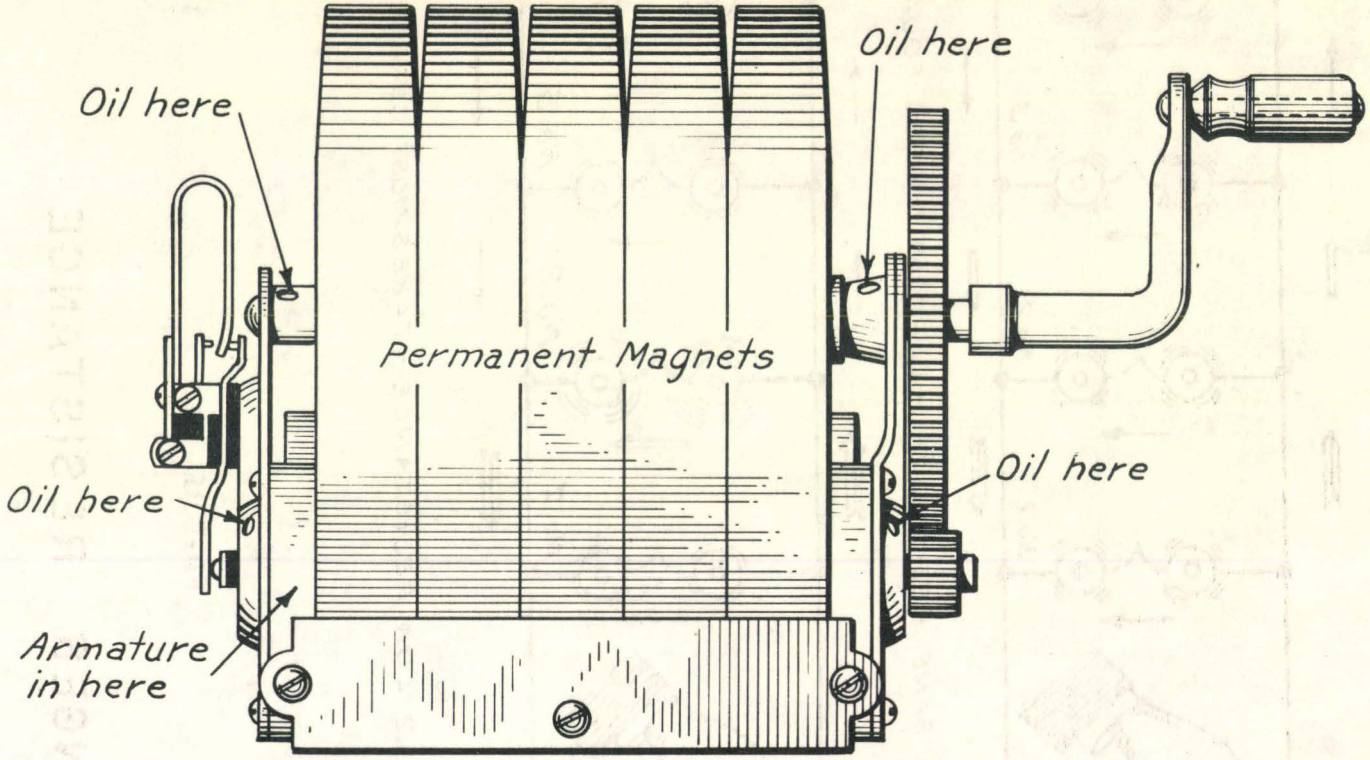


FIGURE 90

THE MAGNETO CONTACT ASSEMBLY

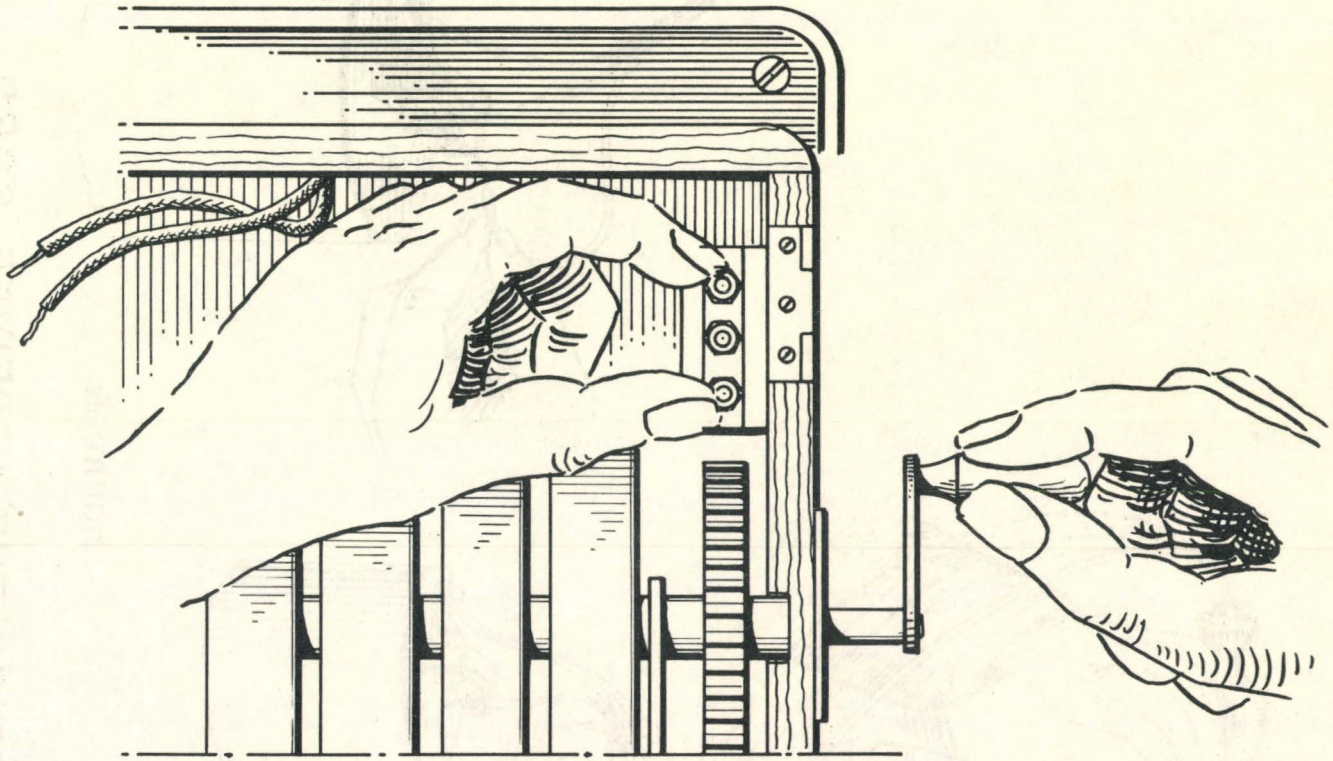


FIGURE 91

TESTING MAGNETO WITH THE FINGER

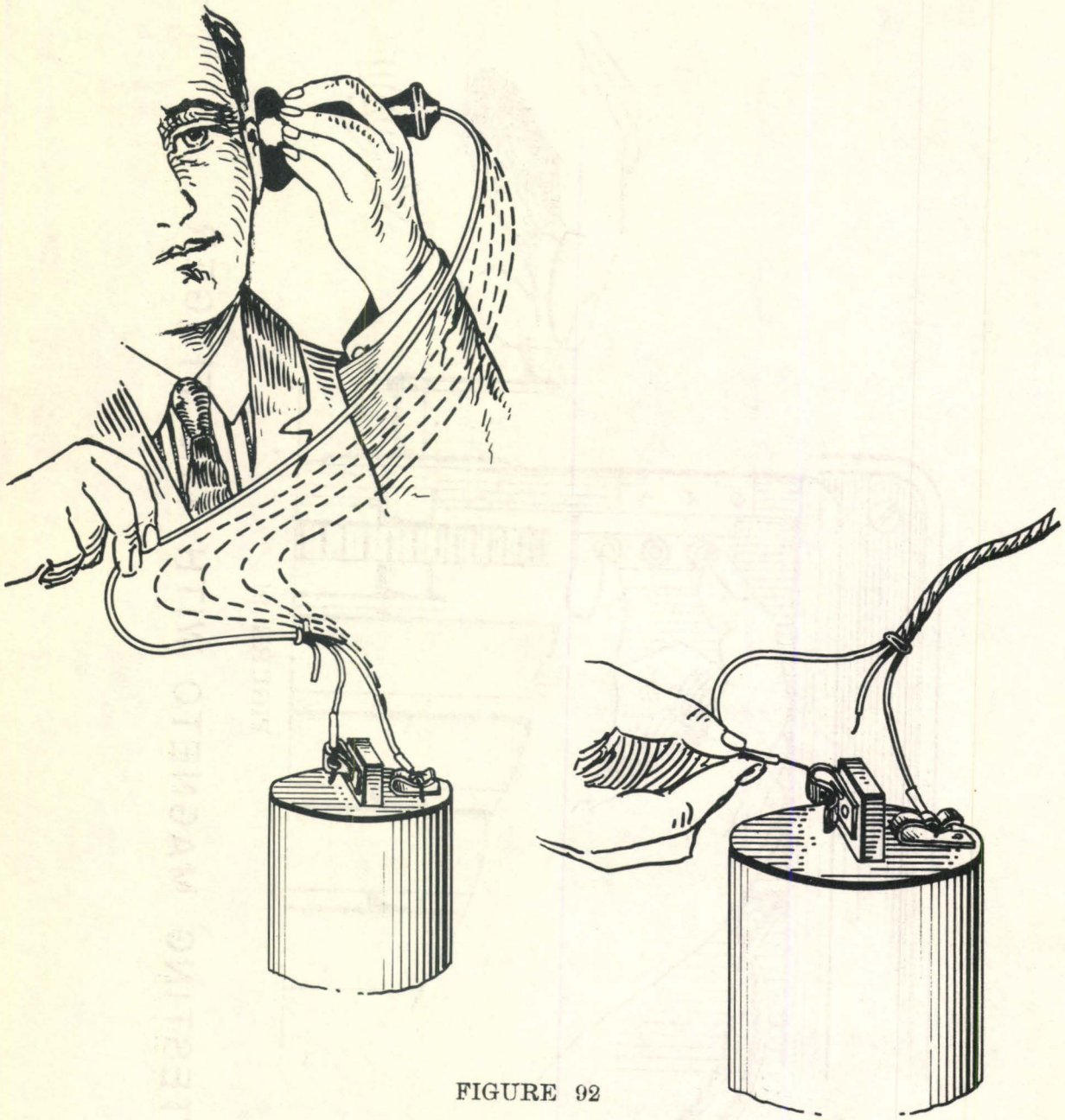
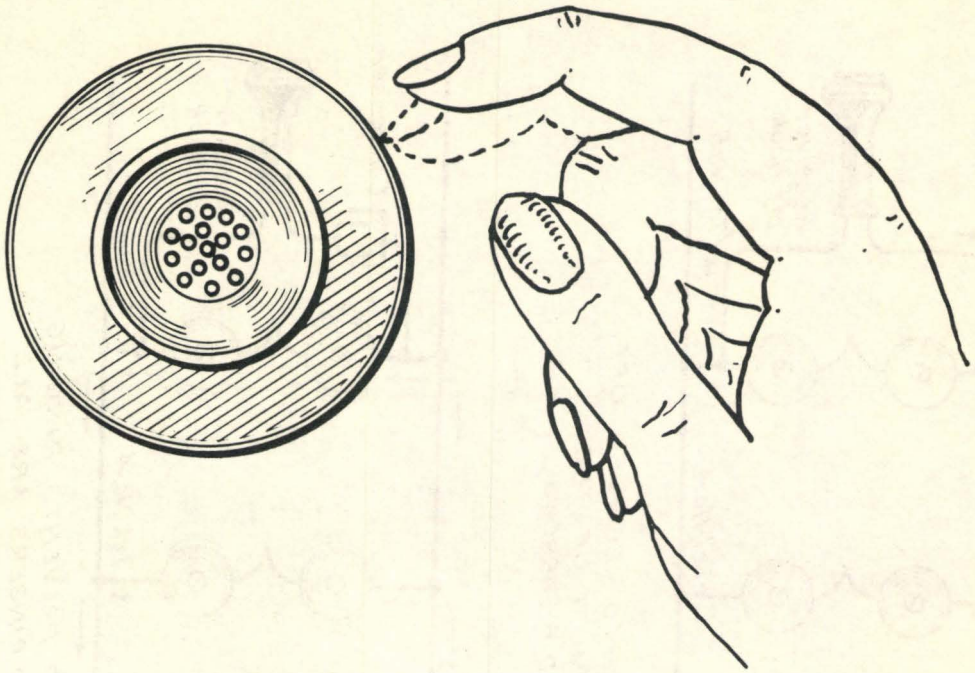


FIGURE 92

TESTING THE RECEIVER CORD



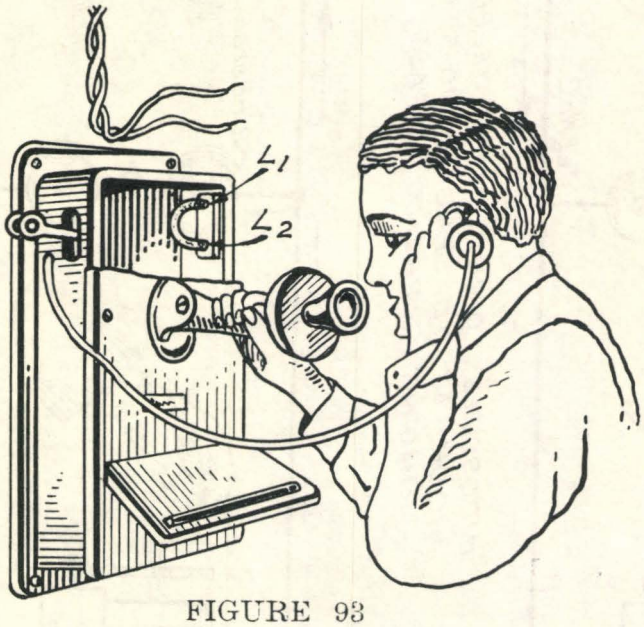
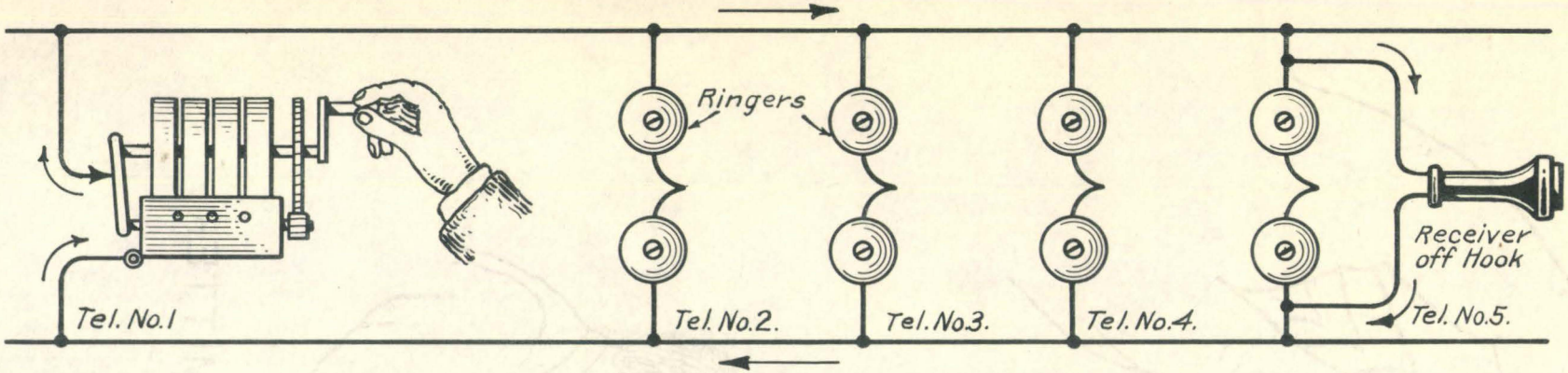
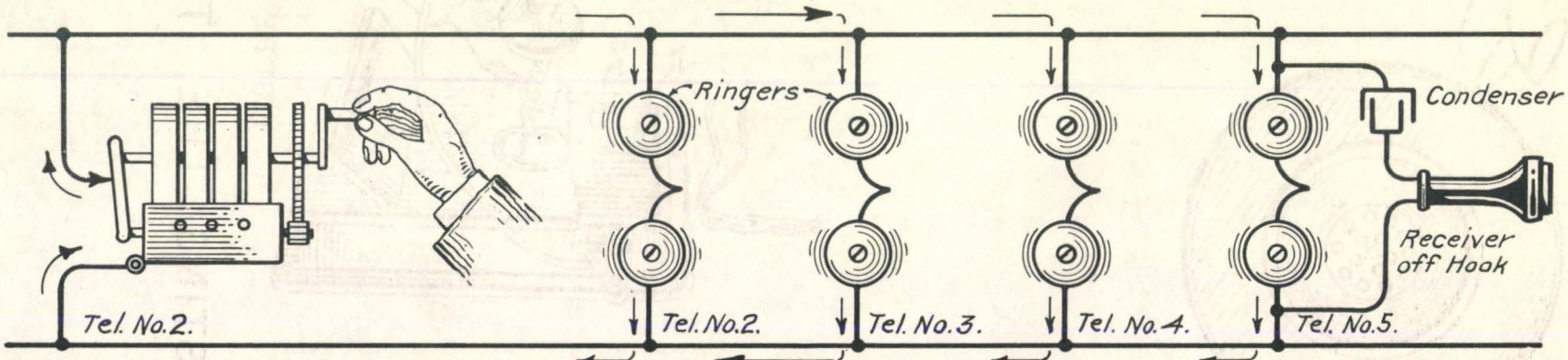


FIGURE 93

TESTING THE TRANSMITTER



IMPOSSIBLE TO RING OTHER TELEPHONES, DUE TO RECEIVER OFF HOOK AT TELEPHONE NO. 5, ALLOWING MOST OF THE RINGING CURRENT TO PASS, INDICATED BY ARROWS



CONDENSER IN CIRCUIT WITH RECEIVER PREVENTS RINGING CURRENT GOING THROUGH RECEIVER, AND RINGERS ARE ALL EASILY RUNG

FIGURE 94

RECEIVER CIRCUITS

SECTION VIII- TELEPHONE TROUBLES

63. Common Causes of Trouble

The most common telephone troubles are caused by line grounds, broken wires, loose connections, poor instrument grounds, and cross or short circuits, and are most likely to be found on the line or in the ground connection. Poor instrument grounds are responsible for much of the ringing difficulty. Trouble may occur in the telephone itself, from any one of the above causes, or as a result of weak batteries. The first step is to determine whether the trouble is on the line or at some telephone station.

A. A ground on any part of a line will interfere more or less with the proper operation of all telephones on that line. It will affect the ringing more than the talking, making it difficult or impossible to ring others.

B. A loose connection or broken wire will make it impossible either to ring or to talk between telephones on opposite sides of the break, but will not interfere with the operation of the line between telephones on the same side of the break.

C. A cross or short circuit in a metallic line will have practically the same effect as a bad ground on the line. Following is a list of some of the most common telephone troubles, with brief instructions for making tests to determine their location. In a general way, the entire telephone circuit is considered as being divided into sections, the tests definitely locating the trouble either in or out of a section. The telephone is usually tested first, then the line fuse, if fuse is used, then the inside wiring, and then the outside wiring, line wires, ground, etc.

64. Use of Magneto in Testing Lines

While a Wheatstone bridge or a voltmeter test set will be of assistance in the hands of an experienced trouble man, the regular telephone magneto can be used to a very good advantage in making most of these tests.

The function of the magneto is to generate electric current. It turns hard or easily in direct proportion to the amount of current or load generated, and this in turn is inversely proportional to the resistance of the wires connected to the magneto.

A heavy ground on the line, or a cross between line wires, is a low resistance connection to the line wire. This allows more than the normal current to flow through the line wire, causing the generator to turn hard.

If the ground or cross is close to the telephone at which the tests are made, the bells at that telephone will not ring when the magneto is turned, as the low resistance circuit made by the ground will take all of the current.

The same ground or cross on the line 10 miles farther away will cause the magneto to turn more easily and the bell may ring a little, since the resistance in the line wire tends to retard the current. On the other hand, the magneto will turn easily if the line wire is broken close to the testing telephone, as there is then practically an open circuit; that is, there is no path for the current to pass, except through the ringer coils at that telephone, and very little current will be generated.

65. Causes and Remedies

A. Your magneto turns hard and does not ring your own bell as it should, and you cannot ring others.

This trouble may be caused by:

(a) Line wire touching trees, brush, or the ground. If it is a metallic circuit line, the wires may be crossed or touching brush or the ground.
(b) Ground or short circuit between spring contacts in the magneto contact assembly, due to insulation being burned out or injured by oil.
(c) Receiver left off hook at a telephone having no condenser in the receiver circuit.
(d) Too many telephones connected to a line.
(e) A telephone with a low resistance ringer coil connected to the line.

Make tests as follows: Leave the receiver on the hook and disconnect the line wire, or wires, from the telephone. If the trouble is in the telephone, the generator will still turn hard. If the trouble is not in the telephone, it will turn easily. In the latter case, it is indicated that the trouble is ahead. The wires should be reconnected and another test made by disconnecting the wires from the vacuum arrester or line wires outside of the building and turning the generator again. If the generator now turns hard, it indicates that the trouble is between the telephone and the last test. If this is the case, the inside wiring should be carefully checked for crossed wires.

If the generator turns easily when making the last test, it indicates that the trouble is ahead, probably caused by crossed wires or the line wire on the ground. In this event, it will be necessary to go over the lines. If the trouble is not located readily, the line wire should be tested section by section, using the same method as above described.

B. <u>You cannot call anyone, nor can anyone call you. Your generator turns easily and rings your own bell. You can hear no one on the line.</u>

This indicates an open line and is usually caused by a broken wire, a burned out fuse, or a loose connection.

Test as follows: Leave the receiver on the hook, and make a connection with a short piece of wire between the binding screws L_1 and L_2 inside the telephone. Then turn the generator. If the trouble is in the telephone, the generator will still turn easily. In this case, it will probably be found that the binding screws L_1 and L_2 have worked loose, or the insulated line wires have broken at these screws. If the generator turns hard, the trouble is ahead. In this event, put a jumper between the line and ground wires, or between the two line wires, if the line is metallic, just outside of the building and test with the generator as before. If it turns easily, it indicates that the trouble is between the telephone and the point outside where the last "jumper" was put on. In this event, look for a burned out fuse or a broken or loose connection in the inside wiring or at the switches. In case the generator turns hard, it indicates that the trouble is still ahead, and is probably caused by a broken ground or line wire.

C. <u>Your bell rings and when you place the receiver to your ear you can hear others, but they cannot hear you at all, or perhaps only faintly.</u>

This can only be trouble in the transmitter circuit and may be caused by:

(a) Weak batteries.
(b) Batteries improperly connected.
(c) Transmitter "set" or "packed".
(d) A broken wire in the telephone.
(e) Switch hook contact springs dirty or not making contact.

Test as follows: The first step will probably be to "shake up" the transmitter. If the trouble is still there look at the battery and the battery connections. If the batteries seem to be all right and properly connected, test the transmitter as indicated in figure 93. The regular solid back type of transmitter seldom gets

out of order, and ordinarily should not be tampered with. If no sound can be heard when the transmitter is tapped, look for a broken wire in the primary or battery circuit.

D. Your telephone bell rings, but you cannot hear anything when you place the receiver to your ear.

This trouble will probably be in the receiver circuit in the telephone and may be caused by:

(a) Dirt in the receiver.
(b) A dent in the receiver diaphragm.
(c) A broken wire in the receiver circuit.
(d) A loose connection.
(e) A burned out condenser.
(f) Switch hook spring contacts out of adjustment.
(g) Receiver cord loose in receiver.
(h) Fine wire in receiver coils burned out by lightning.

Test as follows: Methods of testing the receiver cord and the receiver are described under figure 92. If it is found that there is a broken wire in the receiver cord, two short pieces of small, insulated wire may be used until a new receiver cord can be secured.

E. You cannot ring others and others cannot ring you. Your generator turns easily and rings your bell. You may be able to talk and to hear others fairly well.

On grounded lines this trouble will usually be caused by a poor ground connection; however, poor connections in the inside or outside wires of either a grounded or a metallic line will cause the same trouble. As it is difficult to test the ground connection, the most satisfactory way to locate this trouble is to first make a test for a poor connection. Do this in practically the same manner as described in trouble No. B. If these tests indicate that the inside wires and line connections are all right, the surest solution is to make a new ground connection as described in figure 51.

F. No one can ring you, but you can ring others. Your generator turns easily but does not ring your own bell. You can talk and hear others.

This trouble may be caused by lightning having burned out the wire in the ringer coils, by a faulty bell adjustment, or by a loose connection or broken wire in the ringer circuit in the telephone.

Test as follows: To test the ringer coils, disconnect the instrument wires from both the ringer and the generator. Take two short pieces of wire and connect the generator directly to the ringer

and then turn the generator. If the bell does not ring, it indicates that the fine wire in one or both of the ringer coils has been burned out. In this event, take them out of the frame and substitute good coils. This should not be attempted unless a soldering outfit is at hand. It is better to have a few extra sets available. These should include the ringer frame and coils but not the gongs and nuts. The new set can be easily substituted, and a good coil put in the old frame for future use. It may be possible to make temporary repairs by removing the paper cover from the coils and connecting the burned ends of the fine wire.

G. <u>You cannot ring others, but others can ring you. Your generator turns easily, but your own bell does not ring. You can talk and hear others.</u>

This trouble is probably caused by broken wires at the binding screws of the generator. To make sure that the generator is working properly, test it as described under "Description of Equipment and Circuits in a Telephone".

If no current can be detected at the generator terminals when the handle is turned, examine the spring contacts to see that oil or dust has not collected on them. If they are all right, the generator should be gone over carefully by an experienced telephone man.

H. <u>You ring on one line at a switching station and the extension bell on another line connected to the switchboard rings, although you have not connected these two lines together.</u>

This trouble is caused either by a bad ground wire or a poor ground connection. If the ground wire and connection are all right, make a new ground connection for one of the lines.

I. <u>You are carrying on a conversation with someone at another telephone, and the voice is chopped off or broken.</u>

If you hear the other person all right but your voice is broken, look for a loose connection in the transmitter circuit of your telephone. If your voice is not broken but the other person's voice is broken, the trouble is in the transmitter circuit of the other telephone. If both voices are broken the trouble may be caused by:

(a) A loose connection in the receiving circuit of either telephone.

(b) A loose connection in the inside wiring, lightning protector, fuses, or ground connection at either telephone station.

(c) A line wire loose from the tie and swinging against a ground wire or another line wire.
(d) A broken or partially shorted receiver cord at either telephone.
(e) A switch hook at either telephone with the spring contacts not functioning properly.
(f) A loose connection in the drop wire at either station or in the line wire between these stations.
(g) A bad connection in the line wire.

SECTION IX - MAINTENANCE

66. General

In order to secure good telephone service, the lines must not only be constructed according to the standards laid down in this manual, but must be kept in as good condition as may be consistent with Forest Service modern standards.

Maintenance must be done systematically. All lines, inside wires, switches, telephones, etc., must be examined carefully at least once a year. The following general instructions should be carefully read before work is started.

67. Maintenance of Tree Lines

Study the instructions for tree line construction. It is important that district rangers take an active part in the maintenance of the telephone system of a forest. Keep the lines currently maintained.

A. Down Timber

Remove all limbs or trees that may be down over the line, or that are likely to fall on the wire during the field season. Brush must be disposed of so as not to form a fire menace. See that the line wire has not been injured and that it swings back in place when the obstructions have been removed.

B. Brushing Out

Trim all brush, limbs, etc., to a distance of not less than four feet from the line wire, making due allowance for wind, rain, and snow. Young cottonwoods, alders, and other rapid growth timber should be removed.

C. Tie Wires and Insulators

Inspect all insulators and ties. Replace broken insulators and see that tie wires are twisted tight around insulators. Be sure that ties are hooked into staples so that they will pull loose readily without breaking the line wire. If an insulator is on the wrong side of a tree and the line wire pulls against instead of away from it, either put in a tree pin, swing another insulator from a nearby tree and pull the line wire clear, or change the insulator and wire to the other side of the tree.

D. Connections

Examine line wire closely for loose or rusty splices. If bad connections are found, they should be cut out and good connections made.

E. Breaks

Try to find out what caused the break, and if possible, make changes to avoid a repetition of the trouble.

F. Slack

There should be enough slack in the line wire to permit it being pulled to the ground readily in any span. If the wire is too tight, put in more slack.

G. Ties Pulled out of Staples

Examine the tie wire. If it is damaged, put on a new tie wire and hang properly. If the trouble is due to a strain caused by a sharp bend in the line wire, put on two insulators or change the tie wire to another tree.

H. Drop or Service Wire

Enough slack should be allowed for tree or pole sway and the wires, if more than one, must be far enough apart to prevent crossing. If the service wire is copper, the connection to the line wire should be made with a bridging connector or some other type of solderless connector. If the service wire is iron, the connection should be soldered, or made with 8 or 10 close wraps around the line wire.

I. Vacuum Arresters

Vacuum arresters and line fuses must be properly located. All connections must be tight.

J. Tools and Material

Following is a list of tools and material suggested as necessary for a two man crew for tree line maintenance:

Tools

1 light 16-foot ladder
2 pair 8-inch pliers

1 pair climbers
2 pair connectors
1 double blade axe
1 2½-pound single blade axe, short handle
2 small 2-sheave pulley blocks
2 Klein's or Buffalo grips
50 feet 3/8 or 1/2 inch rope
2 lineman's belts
2 safety straps

Material

Supply of wire of same size and kind as line wire
Supply of staples of various lengths
Supply of split insulators
Supply of iron tree pins
Supply of wood tree pins

68. Maintenance of Pole Lines

Study the instructions for pole line construction.

A. Poles

Inspect each pole for rot at the ground line. Test by pushing against the side of the pole with a shovel. Do not gouge and damage the pole in making the test. If it is not safe, set a stub or a new pole. Straighten up leaning poles unless they were raked intentionally. Put on extra guys if needed.

B. Guys

See that all guys are pulled up tight and that the guy wire is in good condition. If the guy is in a road or other exposed place, a guard stick should be wired to it just above the ground.

C. Line Wires

Cut out bad splices and pull up slack so that all wires have the same tension. See that there is sufficient clearance above the ground at road crossings. Put on new ties where needed and see that crossing with railroad tracks or electric power wires are in good condition.

D. Lightning Conductors

See that the conductor wire is securely stapled to the pole in the proper position.

E. Brackets and Insulators

Replace broken insulators. If brackets are pulled off or loose, replace in the proper position. If the pole is split or has large season checks, it should be wrapped with wire. If brackets are split, put on new ones or use bracket clips.

F. Tools and Material

Following is a list of tools and material suggested for a two man crew for pole line maintenance:

Tools

1 5-foot round pointed shovel
1 hand axe
2 pair climbers
2 pair 8-inch pliers
2 pair connectors
2 lineman's belts
2 safety straps
2 small 2-sheave pulley blocks
2 Klein's or Buffalo grips
50 feet 3/8 or 1/4 inch rope
1 tamping bar

Material

Supply of wire of same size and kind as line wire
Supply of glass insulators
Supply of brackets
Supply of cross arm pins
Supply of 30d and 60d spikes

69. Maintenance, Inside Wiring and Instruments

Study instructions for installing telephones and making ground connections.

A. Insulated Wire

All insulated wire should be No. 14, rubber covered, single braided, copper wire. Wire of inferior quality must be replaced. If the wire hangs loosely and is run in a careless manner, fasten neatly and securely in place with insulated staples.

B. Connections

If there are old connections, examine carefully. If they are

not properly made and soldered, the wire should be replaced with new wire. Tape all bare spots.

C. Switches

Go over all screw contacts and see that the knife blades work freely and fit tight in the spring clips. If it is necessary to make them fit tight, bend the spring clips together. Replace the switches if they are not in good condition.

D. Ground Connections

Go over ground wire and connections carefully. This is very important. See that the soil is moist and that the ground connection is made according to instructions. Do not forget that soil that is moist in the spring may be dry and make a very poor ground in the summer.

E. Extension Bell

See that the binding screws are tight. Test the bells and make the necessary adjustments when the telephone is tested.

F. Batteries

Batteries should be renewed at the beginning of each season.

G. Testing Telephones

See that the screw contacts with the telephone are tight. When the work is completed, make final tests as follows: Disconnect the line wires from the line binding screws L_1 and L_2, and test the magneto and the bell by turning the generator crank. If the bell does not ring properly, look for the trouble and make the proper adjustments. Put a drop or two of oil at each end of the bearings, and see that the spring contacts at the end of the generator work properly. You should be familiar with the section on "Description of Equipment and Circuits in a Telephone".

Remove the receiver from the hook and work the switch hook up and down, leaving the door of the telephone open to see if the spring contacts function properly, as described under "switch hook". Make a final test by calling up some other station on the line and see if you can talk with it satisfactorily, having it ring your bell. If signals do not come in clearly, make adjustments in the telephone bell. Inspect the receiver and see that it is in good condition. Unscrew the cap and clean out the dust from under the diaphragm.

H. Tools and Material

Following is a list of tools and material suggested for a one man crew for inside wiring and instrument maintenance:

Tools

1 medium sized screw driver
1 pair of 8 inch pliers
1 pair long nose pliers, 5"
1 pair side cutting pliers, 6"
1 small hammer

Material

A supply of No. 14 rubber covered copper wire
A roll of tape
1 box Blake insulated staples
3 or 4 feet of 7/32 inch circular loom
1 or 2 receiver cords
1 or 2 receiver diaphragms
Extra connectors
Extra knife switches of the type used
A supply of 1 inch No. 8 round headed screws
3 dry batteries for each telephone

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